SCIENCE

VOL. 101 FRIDAY, MARCH 30, 1945 No. 2622

New Frontiers: PROFESSOR RICHARD STEVENS BURINGTON 313

Obituary:
Recent Deaths 320

Scientific Events:
Wildlife Conservation in Missouri; Award of the Pittsburgh Section of the American Chemical Society; Medals of the Franklin Institute; Predoctoral Fellowships in the Natural Sciences of the National Research Council 321

Scientific Notes and News 323

Discussion:
The Demographic Dilemma: PROFESSOR KARL SAX. *Esterasopenic and Esterasoplenic Peripheral Nerve Terminations:* DR. PHILIP B. ARMSTRONG. *On Direct Vision Characteristics of Spots Producing Terrestrial Magnetic Phenomena:* DR. JAMES C. BARTLETT, JR. *Electronics as a Possible Aid in the Study of Bird Flight and Migration:* PROFESSOR MAURICE BROOKS. *A Tertiary River:* KARL VER STEEG 325

Scientific Books:
Plant Geography: PROFESSOR ORLAND E. WHITE. *Electrotherapy:* DR. RALPH PEMBERTON 330

Reports:
Program of the Institute of Radio Engineers 331

Special Articles:
The Precipitation of Purified Concentrated Influenza Virus and Vaccine on Calcium Phosphate: DR. W. M. STANLEY. *Recording of Sounds Produced by Certain Disease-Carrying Mosquitoes:* PROFESSOR MORTON C. KAHN, WILLIAM CELESTIN and WILLIAM OFFENHAUSER. *The Effect of Penicillin and Certain Sulfa Drugs on the Intracellular Bacteroids of the Cockroach:* PROFESSOR CHARLES T. BRUES and RUTH C. DUNN. *The Occurrence of Normal Serum Gamma-Globulin in Human Lymphocytes:* DR. EDWARD H. KASS. *Retention of Thiamine, Riboflavin and Niacin in Deep Fat Cooking:* DR. GLADYS J. EVERSON and DR. ARTHUR H. SMITH. *Effect of Reduced Atmospheric Pressure on Hatchability of the Hen's Egg:* DR. RICHARD M. FRAPS 332

Scientific Apparatus and Laboratory Methods:
The Use of Ionic Exchange Resins for the Purification of Penicillin and Hypertensin: E. CRUZ-COKE, F. GONZALEZ and W. HULSEN 340

Science News 10

SCIENCE: A Weekly Journal, since 1900 the official organ of the American Association for the Advancement of Science. Published by the American Association for the Advancement of Science every Friday at Lancaster, Pennsylvania.

Editors: JOSEPHINE OWEN CATTELL and JAQUES CATTELL.

Policy Committee: MALCOLM H. SOULE, ROGER ADAMS and WALTER R. MILES.

Advertising Manager: THEO. J. CHRISTENSEN.

Communications relative to articles offered for publication should be addressed to Editors of Science, 34 Gramercy Park, New York 3, N. Y.

Communications relative to advertising should be addressed to THEO. CHRISTENSEN, Advertising Manager, Smithsonian Institution Building, Washington 25, D. C.

Communications relative to membership in the Association and to all matters of business of the Association should be addressed to the Permanent Secretary, A.A.A.S., Smithsonian Institution Building, Washington 25, D. C.

Annual subscription, $6.00 Single copies, 15 cents

NEW FRONTIERS[1]

By Professor RICHARD STEVENS BURINGTON

DEPARTMENT OF MATHEMATICS, THE CASE SCHOOL OF APPLIED SCIENCE (ON LEAVE)
HEAD MATHEMATICIAN, BUREAU OF ORDNANCE, NAVY DEPARTMENT[2]

(1) FOR the past several years it has been my privilege to have intimate contact with a large amount of work concerned with an array of investigations in engineering, physical research and related activities, and with work in which all sorts of mathematical and physical fields appear as fundamental items in the larger problems under study. The nature of this work has been such that much of it, as met, would not be suitable for discussion here. Nevertheless, there are certain important facts and observations which I have noted from time to time that I hope will be of interest to many persons—to engineers, physicists, chemists, investigators, businessmen, industrialists, as well as to pure and applied mathematicians, and university people. Some of these items may well be made the subject of serious study, and such action as may be indicated should then be pushed vigorously by responsible individuals and organizations.

In discussing this topic, "New Frontiers"—some new, some old, some always new—I have in mind the vast store of potentially powerful and valuable mathematical knowledge and talent which has scarcely been tapped by industry and business. I should like to

[1] Address delivered to Section A—Mathematics, American Association for the Advancement of Science, Cleveland, Ohio, September 12, 1944. The author wishes to express his appreciation for the many constructive suggestions and critical comments made in connection with the preparation of this paper by Dr. Arthur Bennett, astronomer and engineer, and by Dr. C. C. Torrance, mathematician.

[2] The opinions expressed in this paper are those of the author and are not necessarily those of the Navy Department.

point out various directions in which some types of mathematicians might well—and should—direct their efforts. I should not presume to indicate the direction which pure research should take, for I doubt that any one should try to do that. I wish, nevertheless, to record certain specific suggestions for further development in mathematics, its applications and its uses in industry. In this connection I shall point out certain items which I believe should be considered by educators in developing their plans for the training of students for useful and fruitful careers, and, particularly, for the training of men and women in the mathematical and physical sciences.

Traditionally, mathematicians have found employment principally as teachers of mathematics. Some of them, along with their teaching, have developed into researchers in pure mathematics. Since the beginning of this century, very few mathematicians in this country have directed their investigations to applied mathematics and a still smaller number have found their way into industrial development and research. That more of these mathematicians have not followed the applied fields can undoubtedly be traced in no small measure to economic factors and to the influence of some of the outstanding schools of mathematics.

Although I have no doubt that this influence has been good so far as it went, I firmly believe that some of these schools should have undertaken vigorous programs years ago for the training of mathematicians for careers in industry and business. Only a few mathematicians recognized this need before the present war; those of us who did were often severely criticized by our colleagues who preached and sought for the crystal pure in their teaching and in their pursuit of pure research.

(2) *The Growth of Analytical Methods.* The expansion of the use of analytical methods in industry received a tremendous impetus at the beginning of this century from the introduction of steel structures and from the birth and growth of the electrical industry. This development of methods spread rapidly to the chemical and motor industries and, more recently, to the aircraft business. The present trend will undoubtedly continue for some time to come. Analytical activities in connection with many urgent development and production programs have been accelerated by the war; although some reduction in this pace can be looked for after the war, a considerable demand will continue, I feel, for a high level of analytical work in industry and for persons competent to handle such work economically and adequately.

The great depletion of material resources which this country has recently suffered demands a reconsideration of our spendthrift methods. Costly, wasteful processes and cut-and-dried methods of development which heretofore have often been the simplest and cheapest and sometimes, perhaps, the only methods available, must be bettered in the future. A much wider use of analytical methods than has been employed in the past will be forced upon many businesses by economic necessity. This need may be filled by the services of competent mathematicians of a new type, provided the men employed are able, by use of their abilities and knowledge, to reduce the need for and cost of experimentation and to aid in eliminating wasteful production. The ever-increasing need for more precise and exacting products and devices entails an ever-increasing need for a high degree of skill on the part of those engaged in research, development and production. With this trend, there is no question in my mind that the properly prepared mathematician should be able, and is able, to cooperate with scientists, engineers and business men at a high level in a most helpful, efficient, economical and satisfactory manner.

(3) *Mathematicians in Industry and Business.* Mathematicians have not been used to any great extent in most businesses. True, actuaries have long been used by insurance companies, and various types of statisticians have been used in most businesses. True, a highly efficient research mathematics department under a director of mathematical research, and staffed by mathematicians of high caliber, has been maintained at a few outstanding organizations such as the Bell Telephone Laboratories. Mathematicians and mathematical physicists have been employed by some aircraft, motor and electrical companies. But, on the whole, the wealth of available mathematical talent is not widely used. Typical situations in many concerns might be something like the following:

(a) No mathematicians are employed and very little mathematical work is done even when a goodly amount of it would yield dividends. Such statistical work as is carried out, if anything beyond a mere compilation of records, is usually done by clerks, accountants, draftsmen, economists, or inadequately trained statistical help. A remarkably good job is done by these persons when one considers their background and the fact that this statistical work is often only a minor part of their many responsibilities. In some cases analytical work is recognized as necessary, but even then, the work is done by engineers and draftsmen who have rather limited knowledge of mathematical technique.

(b) Even in those companies where a very considerable amount of development and research work is carried out, neither the need for nor the value of analytical studies is always appreciated. When the need is recognized the analytical work is carried out

by engineers, physicists, chemists, draftsmen, accountants or statisticians who simply haven't the time to make the most effective use of mathematical methods; are not primarily interested or trained in the mathematical methods; and do not engage the cooperation, services or advice of men whose prime knowledge and abilities are in mathematics. Because these analytical problems arise within the jurisdiction of men in physical science it is natural, but sometimes unfortunate, that these men undertake the studies themselves.

I have seen many instances of these procedures; while the individuals involved do the very best they can, the methods used are frequently crude, and the results often take the form of costly design procedures, excessive use of material and labor and an inferior product. I have seen instances when there existed a real problem requiring a solution, but when there was no appreciation of the existence of this problem on the part of those responsible. There have been instances when the presence of a problem needing an improved solution was appreciated, yet an understanding of the sort of talent needed to produce the desired result was completely lacking. What is needed in these cases is a recognition of the caliber of assistance required and the sound, effective use of mathematicians—men whose perspective and training permits the ready use of methods of which engineers and physicists have some knowledge, but not enough to enable them to choose the most economical and best method. Such mathematicians must be broadly trained in mathematical methods, must be resourceful, and especially must be gifted with an abundance of good sense. Properly trained mathematicians should be able to do for a dollar what others who know something of mathematics, but do not specialize in mathematics, can do for ten dollars. Mathematicians of this sort must retain a high professional standing and should, and do, have the same prestige as other highly qualified professional men.

(4) *Why Mathematicians Have Not Been Utilized More in Business.* One of the reasons for the fact that mathematicians have not been used more extensively in business is probably economic. The attitude of business in general is that a mathematician is a luxury. But as I have stated above the growing scarcity of materials and the high cost of experiment tends to weaken this attitude and to produce a demand for more mathematical work. Another reason lies in the type of training that has been given to mathematicians and the atmosphere in which mathematicians have been reared. Many men who should naturally be in mathematics have been drawn into the physical sciences by better wages, by the pressure of teachers of the physical sciences, or by a complete lack of interest in the physical sciences on the part of their mathematics professors. Furthermore, the experiences of some industrial concerns which have employed a few pure mathematicians have not always been of the best, either because the company did not know how to make the best use of the mathematicians, or because the intuition or the background in the physical sciences of the mathematicians was inadequate. Among the common mistakes made by the mathematician in connection with practical problems are the following:

(a) He is unable to select a sensible set of physical assumptions upon which to formulate his problem.

(b) He exhibits various forms of lack of good sense, either because of lack of physical background or because he has had little acquaintance with men and the ways of the world. Some mathematicians take too many courses or stay in school too long and consequently are considered to be crackpots, geniuses or adolescents.

(c) He likes to overuse mathematics and to revel in bigger and better formulas. He is unable to simplify his results to a form which ordinary men can understand. He seems to feel that his work is finished if he exhibits a set of differential equations or some sort of abstract solution when, actually, his work is not finished until it is in a form suitable for simple computation. In many industrial situations, complete numerical results are the only useful product.

(d) He claims to have proved a physical theory when neither his assumptions nor any of his conclusions have been subjected to the proper physical tests. Very good men have made this mistake.

(e) He changes the essential assumptions of a problem in order to produce either a problem which he can solve or one that is more interesting to him than the problem actually at hand. The simplification of a problem merely to obtain an answer is not always the way out of a practical problem in industry. Such procedures lead to solutions which are often completely worthless in industry or elsewhere. Many good men in mathematics, particularly pure mathematicians, have committed these blunders.

(f) He seems to feel that he is not doing mathematics unless he is immersed in some very advanced branch of the subject, whereas actually the highest type of mathematics needed may be the use of an unusually intelligent train of thinking leading to a sound conclusion. In the end, the actual manipulative techniques used may be extremely elementary and simple—so simple in fact that, after the problem is solved, the ordinary professional man may gain from its simplicity the notion that anybody could have worked the problem in a short time and that the mathematician was not needed.

(5) *Training of Mathematicians.* I believe that mathematicians should continue to be trained for

teaching and for pure mathematical research as has been done in the past, for their work has been good and fruitful, and has contributed much to the training of men in many fields and to the discovery of new knowledge in those fields.

With an industrial demand for mathematicians, which I am sure will grow, there should be trained among the younger people an additional *new group* of mathematicians. The schooling of this new group should be somewhat different from that of the group in the teaching and pure research fields. This group should be trained for service to business and industry. The training should be at least as thorough and rigorous as that given for the doctorate to those men who plan to follow physics or chemistry in the industrial world. This group should have an extensive amount of practical industrial experience involving mathematical and physical activities. Such students should have sufficient training in the physical and engineering sciences to enable them to understand the language of the engineer, scientist and businessman, and the practical problems which they must face. They must have extensive training in the art of translating physical problems into mathematical language, training in the art of approximating a solution when a true solution appears to be impossible or too time-consuming, and training in the skills needed to translate mathematical solutions back into the language of the original physical problem. The details of such training have been outlined in a previous paper.[2] Briefly, the curriculum for such students should include about 50 per cent. pure mathematics, 30 per cent. applied mathematics and 20 per cent. engineering and physical sciences. The training in pure mathematics should be very broad. The courses should be given with the highest standards of rigor now generally in force in our better graduate schools. Comprehensive courses in the fields of analysis, geometry and algebra are required. Work in statistics, probability, graphical and numerical methods should be insisted upon.

The course in applied mathematics should be given with strong emphasis on the physical basis of the material and with greater care in reasoning than is currently manifested by those in the physical sciences who teach such courses. Comprehensive courses in elasticity, electricity and magnetism, analytical dynamics, celestial mechanics, hydro- and aero-dynamics, statistical mechanics, quantum mechanics and optics should be included. The courses in engineering and science should include a number of courses in modern physics and advanced engineering topics.

Mathematicians who are trained according to these principles and who have natural capabilities should, after a reasonable period of experience, have a mathematical consulting background of a value to business and industry which most engineers, physicists and other scientists seldom acquire, and probably should not try to acquire if they are to concentrate their energies on their main occupation of engineering, physics, or other speciality. Such mathematicians should be able to furnish industry and their scientific colleagues with a vast store of mathematical methods which are hardly dreamed of by their scientific friends, and which in the normal course of events remain buried in little seen mathematical journals. These mathematicians should exhibit an ability to abstract and formulate problems—an ability rarely possessed by their professional friends in other fields. They should know the methods of calculation and procedures which will greatly help their colleagues and the industries in which they are working.

This program will require a new ability and breadth of thought on the part of the faculties undertaking it. Various industrial concerns may have to be shown not only the need for the finished product—the mathematician—but also the facilities which they themselves have for aiding in the development of this type of mathematician.

(6) *Fields of Activity for This New Group of Mathematicians.* If mathematicians are trained in accordance with the suggestions mentioned above, then they can be profitably employed, not only in teaching and pure research positions, but in many other types of positions as well, such as:

(a) In the great research laboratories, both private and public, devoted to either practical or theoretical investigations.

(b) In a large number of industries, utilities and businesses which require planning, operational analysis, development and research.

(c) In government laboratories and related research organizations which must continue to devote their energies to the development and improvement of national defense.

(7) *Operational Analysis.* One needs only to read the financial reports of any large public utility, business or transportation system to comprehend the extremely small margin of profit between expenses and revenue; to realize how carefully such concerns must be operated, and how disastrous only a slight change in policy or methods or circumstances can be. This leads me to a discussion of a field which has *long* existed, in some form or another, but which has been only too little recognized; namely, the field of *operational* analysis. This form of analysis should be employed properly by every large concern which wishes to improve its product, and to maintain and increase a spirit of service to the public. In any group charged with operational analysis there is need

[2] Richard S. Burington, *Jour. Eng. Educ.*, 32: 4, December, 1941.

for people of many types and professions; such a group should include mathematicians with a broad understanding of the physical and engineering sciences as well as of statistics and business.

To illustrate what I have in mind, consider a transportation system—a common carrier operating a business of handling freight and passengers by air, water, rail or highway. Such a business is a tremendous one which ranges widely over the fields of finance, law, regulation, engineering, science, public relations, and so on. We can all think of isolated examples of the use of mathematical methods in certain phases of this business, such as in the routine compilation of statistical reports, efficiency studies, the design of bridges, the search for better materials, the study of the dynamics of rolling stock and the improvement of roadbeds. Most of this work is done by clerks, accountants, draftsmen or engineers. Some of it might be simplified and improved with the help of competent mathematicians. What I have in mind for mathematicians is beyond these routine activities. Such an organization should and often does have an operational group staffed by technical men from many different fields, men of broad understanding, sound intelligence and good sense. This group should include experienced and expert mathematicians and should report to a vice-president or other high-ranking officer who is primarily responsible for operations. The duties of such a group should include broad analytical studies of current modes of operations, and penetrating studies leading to improved methods and modes of operations which would in turn lead to decreased costs, more efficient service, better utilization of facilities and improved working conditions for the employees. The resulting healthy financial status would permit further desirable changes, improved facilities and equipment, and ultimately would lead to improved safety and service to the public. Such a group should be far more than a group of "efficiency experts." It should be so organized that it is subjected to a minimum amount of interference from individuals and groups who are swayed by tradition or a passion for the *status quo* or who fear a loss or change of their jobs. Similar groups should be, and usually are, set up in connection with the planning, development and research activities in the system, but I believe that the inclusion of competent mathematicians in such groups would be found to be both wise and profitable to the parent organization.

To illustrate something of what I mean, I shall give two examples:

(a) Recently a new engineer was assigned to a supervisory position entailing the design of certain types of structures which weigh many tons, and which have to be supported in water by floats. For many years the routine improvements and variations in these structures were made by engineers according to a sort of rule of thumb process which had grown up over a period of many years. None of the former engineers in charge of this work had ever even thought that the design problem could be handled successfully by mathematical methods. The new engineer thought differently but could not produce the solution. Instead of giving up he sought the advice of a competent mathematical consultant. The result was a completely new analytical method which solves the design problem by a procedure which is capable of yielding results to any desired degree of accuracy and can be carried through simply and quickly by any draftsman. The type of mathematics needed in the end was elementary, but the thinking required to produce this result involved a high order of mathematical intelligence.

(b) A few years ago an association of electric traction concerns organized and financed a group of scientists and engineers to study possible improvements in electric traction facilities and service. One of the most fruitful results of the work of this group has been the development of the light-weight, high-speed, rapidly accelerating and decelerating street-car which has so greatly improved the comfort and speed of service in some of our cities. In connection with this project, serious mathematical studies were made of the performance and dynamical characteristics of street-car trucks and of the car as a whole. These studies involved very difficult problems in analytical dynamics and function theory. They included an attempt to determine the best type of wheel, the best shape of wheel flange, the best shape of rail head, optimum spring suspension, the best way of mounting motors in trucks and the most efficient form of brake. Some of the most difficult work was done with the expert help of a man primarily trained in mathematics who in later years had become, both in theory and practice, a development and research engineer of the first magnitude.

A similar situation exists in the railroad field. Tremendous activities are afoot which point to radical changes and improvements in rolling stock.

An example of another type of problem met by a railroad is the freight tariff. Any one who could make a freight tariff which is simple to read and to understand and which still meets the many rulings which have accumulated over the years would do a wonderful service. I have often thought that a good mathematician, once he learned enough about tariffs, might make striking progress in this direction, provided the multitudinous pressure groups, regulatory bodies and dyed-in-the-wool tariff men would let him.

One of the difficulties and challenges which an operational group faces arises from the fact that the actions of any transportation system (and of many

other businesses also) are subject to serious boundary conditions—conditions which often are incompatible and tend to be destructive. These boundary conditions arise in many ways; the dominant sources may easily be traced to two essentially independent sets of statutes one of which is administered by a body which regulates revenue by the fixing of rates, and the other by a board or other regulatory system which fixes the cost of labor. In most cases the actions of these regulatory bodies are entirely independent. Some of the effects of this system of regulation are evidenced in the set accounting procedures, safety regulations and rules governing the utilization of employees. Many an obvious improvement is never put into effect because of the seemingly unsurmountable difficulties resulting from a multitude of laws, regulations and traditions, and because of the difficulties involved in getting these hindering laws, regulations and traditions revised to permit the proposed improvements. These complicated boundary conditions are a challenge to the management of any transportation system and, in a similar way, to any operational group. The mathematician should be of value in solving such problems because of his special ability to organize a mass of details into a few simple formulas or principles.

What I have just said concerning a transportation system applies in a similar manner to almost every industry and business. There are many instances where mathematicians would prove to be of service if they were properly trained.

(8) *Cooperation with Engineers and Scientists on the Part of Mathematicians is Essential, but the Autonomy of Mathematicians is Desirable.* For a business to get the most out of a mathematician, the business administration must have an appreciation of the scope and limitations of mathematicians. Experience shows that, in order for a mathematician or other consultant to be of continuing service to industry, he must have his duties so arranged that he can keep up with the scientific literature and the developments in his own and related fields. Some universities have appreciated this need and have been reasonably careful in assigning loads to those members of their faculties who were interested in or engaged in research work. Industries, research laboratories and other agencies who expect to make the best use of scientific help should fully realize this. There is no such thing as mass production of creative thinking.

It is well to observe that mathematics is just as much a profession as physics or chemical engineering. It is necessary to maintain the autonomy of mathematics just as completely as that of physics or mechanical engineering. Domination may drive, but it can not inspire. If mathematics is to continue to develop and furnish improved tools for analysis and computation, human experience shows that mathematics must retain its entity—subject, of course, to the sort of cooperation which is the theme of this paper. This policy is essential if the storehouse of mathematical knowledge is to be maintained and increased for the benefit of the other sciences and for mankind as a whole. These are some of the principal reasons why mathematics has continued in most universities as a department on its own, as it should, and has not been made a part of a physics department or of some engineering department, wherein it would lose its identity.

(9) *Frontiers for Investigation in Physical Mathematics.* In recent years the style of research in physics has been toward quantum mechanics, nuclear physics, and the like. It has been commonly thought that there was no need for further investigations into the broader so-called classical fields of physics, such as electricity, magnetism, sound, and hydrodynamics. Our experience in this war has only too clearly shown how shortsighted this attitude has been. Actually we know appallingly little about most of these broad fields; here there are many matters for fundamental study by both physicists and mathematicians.

There is no field of physics, either ultra-modern or classical, that is not a veritable mine of inspiration and guidance for further mathematical inquiry. I can heartily recommend to any mathematician, pure or applied, or of the type that I have described above, that he examine one or more of these fields. If he is any kind of investigator at all, he will come away with inspiration for thought and search. If he is a pure mathematician, while he can not become an expert in an applied field over night—as some have thought during this war—he will at least have some vivid and stimulating impressions. He may sense the need for improved mathematical descriptions of physical phenomena—particularly for descriptions which can be derived from observation and experiment. If he looks a little further, he will find that his natural tendency as a pure mathematician to develop his theories and to obtain the greatest possible generalization is not always the most fruitful pursuit. He will find that, more often than not, some physical restraint usually limits generalization in a way which he, as a pure mathematician, may think to be wrong; but unrestricted generalization will commonly lead to results which are completely worthless in the physical sense.

One fact which some pure mathematicians never seem to learn is that the act of writing a mathematical paper in physical language does not make it an applied mathematical paper. Such practices can actually be bordering on fraud. On the other side, many

physicists, engineers and chemists mistake papers involving mathematical processes for mathematical research, whereas such papers are not mathematical research at all, but physical studies involving mathematical language.

Another fact which a pure mathematician can not learn too quickly is that, in physical mathematics, a job is often not finished until actual numerical results are obtained. This fact suggests a consideration of computational processes.

(10) *Computational Processes.* Problems, often of a very difficult nature, are continually arising which involve extensive computation and which, therefore, require a large amount of work to carry through. Great strides have been made and are now being made in the development of machines capable of computing a vast variety of things. Even after such machines have been adequately developed by men skilled in such fields there is still a big job for the mathematician. These machines do not and can not think, and, therefore, can not evolve new processes. Mathematicians should try to discover mathematical processes which will greatly reduce, if not completely eliminate, the need of these machines in some processes. For example, I know of certain calculations being done by machine which can be done much more simply and more quickly by a graphical process with which any eighth-grader can obtain an answer as accurate as the problem may require. This process was evolved by excellent mathematical methods.

One field which is encountered frequently in working problems in electricity, elasticity and hydrodynamics involves the solution of partial differential equations with very nasty boundary conditions. True, there are various analytical methods of obtaining the complete solution of some of these problems, and numerical processes have been devised for carrying through approximate solutions in many cases. I believe, however, that there is much room for advance in these fields. A practical solution might entail new types of computing machines, such as the engineer has developed for the study of strains in structures by photo-elastic methods suitable for two-dimensional studies but with the scope of the method extended to three-dimensions. The alert mathematician should, however, contemplate an entirely *new* mathematical approach for solving such problems numerically without the need of such elaborate model studies with, perhaps, either no need for a machine or, at most, a machine which is simple and produces results with speed.

(11) *Statistics.* Much of the statistics commonly in use in business and industry has been developed by people who are not mathematically trained. This product has been useful and some of it is very good. I am sure it would be done even better and would be of more use if mathematically trained men were to assist in its development. In particular, it would have been possible to avoid numerous examples of profound nonsense which have found their way into routine statistics, had more good mathematicians been consulted in the past. In this field alone, if mathematicians had taken more interest long ago, there would have been a much greater market and demand for mathematically trained people. To-day there are several excellent schools of mathematical statistics, and they are engaged in consulting service which is at times valuable to those who make use of them.

One of the things I have noticed about mathematical statisticians is that they often produce reams of tables and graphs with the result that they completely bewilder the individuals or the concerns interested in the results. Statisticians must learn how to present their results simply and attractively and must present those results in such a way that any normal individual in the business concerned can grasp their import readily and quickly. If they are unable to come to any proper conclusions because of lack of information or for some other reason, they should bring the matter out completely in the open. In any case, they must be honest and must clearly state the nature of their premises and the degree to which their results depend thereon for reliability.

(12) *Algebra.* There has been a very decided rise in the level of algebraic processes used in engineering design and research in general. Since there is still a great lack of simple numerical means of carrying out needed calculations, I think that a fresh approach to these problems is required with the primary purpose not the discovery of new algebras, but rather the development of simple computational schemes. For example, many uses of the discriminant are encountered in dynamic problems where numerical values of the roots must be found. You may say "get a computing machine," but what is needed is something far better. Mathematical improvements in the calculations relative to the theory of sets of quadratic forms and related matrix algebra would find an immediate use with those who use such mathematics in electrical circuit theory, in dynamics and in the study of the physical properties of crystals.

Many investigators in mathematics have the opinion that as soon as they have exhibited a set of fundamental theorems they are through with the job; actually, they have just started in the practical sense. For, while the theoretical processes may have been reduced to a minimum of simplicity, the practical problem may still be of immense difficulty. The true mathematician should see his work through the ultimate stages of its practical and effective use, and he must insure that, in its final form, the process is ready for utilization by men of little training or background.

(13) *Invariants.* Most mathematicians have a good

understanding of the role that invariance plays in various branches of mathematics. But the mathematician will learn that he must pay more attention to invariants when he embarks upon any physical application of mathematics, for in some form or another, invariants and their discovery are of fundamental importance in the development of any physical science. The fact that the heyday for the researcher in algebraic invariants passed with the discovery of Hilbert's basis theorem in no way reduces the importance of a conscientious search and high respect for invariant properties when working in physical mathematics. Thus, with the rapid development of plastics, glass, plywood, fabrics and wood products, a whole new study must be made to determine their invariantive properties, such as strength, brittleness, fatigue resistance, viscosity, crack-propagation and the influence of external conditions. The uncertainty in the application of the earlier theories of elasticity is a problem in this connection. Serious attention must be given to more general or new theories of elasticity, and along with this must come a search for an improved mathematics capable of describing adequately the theory and its adaptations to the use of engineers. Some of this theory may require a broader use of statistical and probability methods. Undoubtedly, lying moldering in the archives of libraries, there are general solutions to some of these problems already nearly worked out which, with some modernization and extension, may yet prove of real value. Real progress will not result until the practical problems of the engineer can be solved quickly in the form in which they arise in practice. Model studies have been useful, but there is still wide scope for true progress in this field.

(14) *Biophysics.* In recent years there have been many papers in mathematical biophysics which are concerned with quantitative theories of a wide variety of biological phenomena. Quantitative types of biological theory are many years behind their analogues in physical science. As these theories progress, it may well be that they require new mathematical theories or that they require a more expert use of known mathematical techniques than biologists and the medical profession can be expected to possess. This field may need the services of mathematicians with a training and interest in the biological sciences.

(15) *Hydrodynamics Aerodynamics.* Much of the mathematics which is being written on problems in aerodynamics and hydrodynamics can not adequately describe or predict such phenomena. Mathematicians who attempt to work in those fields should concern themselves with an understanding of the phenomena which can be treated by their theories. They should spend a considerable period in studying experimental data in order to adapt their theory more nearly to actual situations. Aside from a great multitude of aerodynamic problems which are still to be solved, the mathematician with good physical background will find large fields of research relating to the nature of the destructive action of cavitation, the behavior of blade profiles when the velocity approaches that of sound, or the theory of stress due to the collapse of vapor bubbles in a liquid. These, and other fields, are still scarcely touched.

(16) *Importance of This Program to the Nation. Summary.* It is without question most necessary for the national interest and for the preservation of peace in the years to come that we encourage and maintain a high level of research in this country, both in the pure and the applied sciences. Accordingly, I consider the program proposed herein to be of considerable importance.

I have indicated some of the directions in which mathematicians should concentrate their efforts. I consider the program suggested herein as intended to *supplement* the older philosophy which has prevailed for many years.

I have urged that pure mathematical research be given continued emphasis and encouragement, but in addition, it is most necessary that a new high level of research in physical mathematics be encouraged and maintained in the years to come to a far greater extent than ever in the past.

This program entails a new training program to produce new types of mathematicians; and this will require the whole-hearted cooperation of educational institutions and many businesses and industries.

It would then seem most natural for mathematicians to find their way into industry on a much larger scale than ever before, and for industry to take much greater advantage of existing mathematical knowledge and talent than ever before. So I say to mathematicians, "By your deeds prove your worth"; and to industry, business and research organizations I say, "Take fuller cognizance of mathematical methods and mathematicians, and by all means make a fuller and wiser use of them than you ever have before."

OBITUARY

RECENT DEATHS

DR. EDMUND BURKE DELABARRE, professor emeritus of psychology of Brown University, has died at the age of eighty-one years.

DR. JOHN C. GRILL, head of the department of pathology of the Marquette University School of Medicine at Milwaukee, died on March 17 at the age of fifty-two years.

DR. STEPHEN PATRICK BURKE, professor of chemical engineering at Columbia University, died on March 10 at the age of forty-eight years.

ALBERT HOWARD HORTON, chief of the Power Resources Division and district engineer of the U. S. Geological Survey, died in Washington, D. C., on March 4 at the age of sixty-nine years. He had been employed as a Federal engineer for nearly forty-seven years, of which nearly forty-two were spent in the Geological Survey, where he has been regarded as an authority on surface water and power resources.

HAROLD RYLAND SMALLEY, director of soil improvement work and for more than twenty-five years a member of the staff of the National Fertilizer Association, died on February 27 at the age of fifty-eight years.

HENRY KRIEGER MCCONNELL, vice-president of the Tobacco By-Products and Chemical Corporation of Louisville and Richmond, known for his work on the production of nicotine and its derivatives, died suddenly on February 25.

DR. ALBRECHT PENCK, professor of geography, emeritus, of the University of Berlin, has died in Prague at the age of eighty-seven years. Dr. Penck occupied the Silliman chair at Yale University in 1908 and acted as Kaiser Wilhelm exchange professor at Columbia University the following year.

SCIENTIFIC EVENTS

WILDLIFE CONSERVATION IN MISSOURI

THE activities of the University of Missouri in the field of wildlife conservation will be expanded to include studies on methods of increasing the fish population of the streams, lakes and ponds of the state. This expansion has been made possible by a bequest amounting to approximately $150,000 made by the late William James Rucker, who died at Charlottesville, Va., on December 19, 1941.

Mr. Rucker was a native Missourian, born at St. James in 1873. He was well known as a substantial contributor to the support of various hospitals, including St. Luke's Hospital in St. Louis and Martha Jefferson Hospital in Charlottesville; he was also active in his support of the Protestant Episcopal Church at Rolla, St. James and Charlottesville. He was deeply interested in wildlife conservation as an active member of the Izaak Walton League, and his bequest to the University of Missouri for the purpose of educating the youth of Missouri in wildlife conservation was apparently motivated by a desire to further the principles and plans formulated by the Missouri Conservation Commission.

As a memorial to Mr. Rucker the Board of Curators of the university has created a Rucker professorship of zoology, and has announced the appointment of Professor Rudolf Bennitt to the new professorship. Professor Bennitt, since 1927 a member of the faculty, holds degrees from Boston and Harvard Universities. With the organization of the Missouri Cooperative Wildlife Research Unit in 1937, he became chairman of its administrative committee.

The expansion of teaching and research in wildlife conservation will be principally in the field of aquatic biology and will be under the supervision of Dr. Robert S. Campbell, who was recently appointed assistant professor of zoology.

AWARD OF THE PITTSBURGH SECTION OF THE AMERICAN CHEMICAL SOCIETY

LEONARD H. CRETCHER, assistant director of the Mellon Institute of Industrial Research and head of the department of research in pure chemistry, as already announced in SCIENCE, received the 1944 award of the Pittsburgh Section of the American Chemical Society at a dinner meeting of the section on February 15. Dr. E. E. Marbaker, of Mellon Institute, presided as toastmaster. The program included brief speeches on various phases of Dr. Cretcher's professional career by Dr. Robert S. Tipson, of the department of research in pure chemistry of the Mellon Institute; Dr. W. W. G. Maclachlan, associate professor of medicine at the University of Pittsburgh and chief of medicine at Mercy Hospital, and Dr. E. R. Weidlein, director of Mellon Institute.

Dr. W. A. Gruse, who was chairman of the Pittsburgh Award Committee for 1944, presented the medalist to Dr. H. K. Work, chairman of the Pittsburgh Section, who conferred the award in recognition "of his eminence in the fields of organic and biochemistry, his successful investigations of the constitution of the carbohydrates present in marine vegetation, his outstanding achievements in the selection and synthesis of anti-pneumococcic and anti-malarial therapeutic agents, and his marked ability in the directing of theoretical and industrial research in the field of chemistry."

The following details in regard to Dr. Cretcher's life and career are taken from the official statement:

Dr. Cretcher was born at DeGraff, Ohio, in 1888, and received his A.B. from the University of Michigan and his Ph.D. from Yale. He taught at the Universities of Michigan and Tennessee and was associated with the Rockefeller Institute for Medical Research, where he worked with the great biochemist, P. A. Levene. During World War I he served in the chemical service branch of the National Army in France and became a Captain in the Chemical Warfare Service. He has had a distinguished career as a research and industrial chemist.

In 1920, Dr. Cretcher became assistant chief chemist for the National Aniline Company and later became research chemist. His first association with Mellon Institute was in 1922 as senior fellow in pure research. Some 25 patents and 70 technical papers have resulted from the investigations of Dr. Cretcher and his co-workers on fundamental phases of specialized fields in organic chemistry in this period. Of particular importance has been his study of quinine derivatives and other cinchona alkaloids as drugs for curing pneumonia caused by the pneumococcus; this investigation culminated in the discovery of the value of hydroxyethylapocupreine as an antipneumococcic drug. Dr. Cretcher's career has been characterized by exceptional ability in the selection and supervision of research personnel.

Dr. Cretcher, the eleventh recipient of the Pittsburgh Award, has been active in the affairs of the American Chemical Society. He served as chairman of the Pittsburgh Section in 1931 and has been a councilor of the section since 1932.

MEDALS OF THE FRANKLIN INSTITUTE

THE annual Medal Day ceremonies of the Franklin Institute, Philadelphia, will be held on April 18. As already announced in SCIENCE, the Elliott Cresson Gold Medals for 1945 "for discovery or original research, adding to the sum of human knowledge, irrespective of commercial value" will be presented to Rear Admiral Stanford Caldwell Hooper, U.S.N., retired, for his work in radio for the U. S. Navy, and to Professor Lewis F. Moody, of Princeton University, for his work on the design and development of hydraulic turbines and pumps.

The Frank P. Brown silver medal given annually "for inventions and discoveries involving meritorious improvements in the building and allied industries" will be presented to Gilmore David Clarke, dean of the College of Architecture, Cornell University, "in consideration of his technical ability, foresight, initiative and outstanding leadership in the field of town and city planning."

Dr. Zay Jeffries, a vice-president of the General Electric Company, will receive the Francis J. Clamer silver medal "for his meritorious contributions to the science of metals, which he has placed on a new and more intelligible basis."

PREDOCTORAL FELLOWSHIPS IN THE NATURAL SCIENCES OF THE NATIONAL RESEARCH COUNCIL

THE National Research Council announces that it is the recipient of a grant of $335,000 from the Rockefeller Foundation for the establishment of a temporary, nation-wide program of predoctoral fellowships for graduate study in the natural sciences. The fellowships are designed to encourage resumption of graduate study by young men who have had to interrupt their education to engage in war work, by enabling them to devote essentially full time to the completion of their work for the doctor's degree. In view of the uncertainty of the duration of the war it is not expected that the program can be inaugurated immediately. This preliminary announcement is made so that young men now in war work will realize that perseverance in their present important tasks will not prejudice their opportunity to pursue their formal education later, and that it may be inadvisable to make commitments at present for postwar employment.

Plans for administration of the fellowships and methods for the selection of candidates are not yet worked out in detail, but it is intended that stipends will be fixed at rates to compare favorably with most other fellowships at this stage of training.

The council and the foundation have developed this program to help to alleviate the very serious set-back to American scientific competence resulting from the war's interference with normal educational processes. The almost complete cessation of consecutive professional training which has occurred in scientific fields will make impossible for some time the normal accession of additional highly trained personnel. These losses, in the face of sharply increasing demands for such personnel, will inevitably retard to the danger point the resumption of scientific progress after the war. The resulting handicap to postwar industrial recovery, public health and military security is a matter of national concern.

It should be realized, however, that this generous grant is sufficient to furnish financial assistance to only a moderate fraction of all graduate students who should resume study for advanced professional degrees in the natural sciences and that, therefore, other types of assistance heretofore available should not be curtailed. The program is planned also not to divert too many qualified candidates from part-time teaching positions, since it is expected that colleges and universities will, after the war, be overburdened with undergraduate students in these fields.

The National Research Council will continue to administer its postdoctoral fellowship program, which

has been such an outstanding factor in building up the scientific competence of the country, and which has thereby contributed essentially to the effort in meeting the present crisis.

SCIENTIFIC NOTES AND NEWS

IN recognition of outstanding achievements in research in the nutrition of infants and children, Dr. S. Z. Levine, professor of pediatrics at Cornell University Medical College, and Dr. Henry Gordon, assistant professor, are joint recipients of the first annual Borden Award to be presented under the auspices of the American Academy of Pediatrics. The award carries with it a gold medal and the sum of $1,000.

THE Herty Medal of the State College for Women at Milledgeville, Ga., has been awarded to Dr. Paul N. Gross, head of the department of chemistry of Duke University, in recognition of research on tobacco.

THE Nicholas Appert Medal of the Institute of Food Technologists has been conferred on Dr. A. W. Bitting, of Lafayette, Ind., in recognition of his work as food technologist for the Bureau of Chemistry of the U. S. Department of Agriculture and for the National Canners Association, as director of research for the Glass Container Association and as a consulting food technologist.

DR. E. EMMET REID, professor emeritus of chemistry of the Johns Hopkins University, has been elected an honorary member of the American Institute of Chemists, in recognition of "his contribution to organic chemistry and his outstanding services to the profession of chemist."

AMONG the degrees conferred by the University of California at Berkeley, on the occasion of its Charter Day exercises on March 23, were the doctorate of laws on Dr. J. N. LeConte, professor of mathematics emeritus, and on Dr. Wilbur A. Sawyer, director emeritus of the International Health Division of the Rockefeller Foundation.

THE sixtieth birthday of Dr. Carl L. A. Schmidt, professor of biochemistry and chairman of the division of the University of California, was celebrated by a tea held on March 9. In honor of the occasion, a portrait of Professor Schmidt was unveiled and he was presented with a bound volume of congratulatory letters from his students and associates.

ON the occasion of his seventy-third birthday, distinguished colleagues, students and Resistance members gathered in the Sorbonne to pay tribute to Professor Paul Langevin, of the University of Paris. Gustave Roussy, rector of the university, and Professor Lablenié, president of the National Front of Universities, spoke in praise of their colleague as "the embodiment of French freedom of thought." Langevin's achievements in the scientific field, which include research on the electron and magnetism and the discovery of principles concerning modern submarine detection, were reviewed by Dr. Amié Cotton and Professor Frédéric Joliot-Curie of the Academy of Sciences.

A MEMORIAL volume has been issued in Sweden in honor of the sixtieth birthday of Dr. The Svedberg, professor of chemistry at the University of Uppsala and director of the Institute of Physical Chemistry.

A CHAPTER of the Society of the Sigma Xi was installed at the Catholic University of America, Washington, D. C., on March 12. Dr. Harlow Shapley, national president of the society, and Dr. George A. Baitsell, executive secretary, were the installing officers. Dr. Shapley gave the installation address and the charge to the chapter. The following officers were elected: Karl F. Herzfeld, *President;* Edward G. Reinhard, *Vice-president;* W. Gardner Lynn, *Secretary-Treasurer.* After a reception and dinner the National Sigma Xi Lecture was delivered by the Reverend James B. Macelwane, S.J., dean of the Institute of Geophysical Technology of Saint Louis University, who spoke on "The Interior of the Earth."

NEW officers for 1945 of the Society of Economic Geologists are O. E. Meinzer, *President;* T. B. Nolan, *First Vice-president;* J. T. Singewald, Jr., *Treasurer;* C. H. Behre, Jr., *Secretary.*

DR. CLAY B. FREUDENBERGER, professor and head of the department of anatomy of the University of Utah, is spending the spring quarter as visiting professor of anatomy at the School of Medicine of the Louisiana State University.

GERALD M. CLEMENCE has been appointed director of the Nautical Almanac Office, U. S. Naval Observatory. He is succeeded as assistant director by Dr. Paul Herget.

DR. R. P. ANDERSON, member *ex-officio* of the Board of Directors of the American Standards Association, past-chairman of the Standards Council and secretary of the Division of Refining of the American Petroleum Institute, has retired from active duty after serving the association for eleven years.

DR. LLOYD PRESTON SMITH, professor of physics at Cornell University, has been appointed associate research director of the laboratories of the Radio Cor-

poration of America at Princeton, N. J. The appointment fills a vacancy caused by the death last July of B. J. Thompson, who was killed in action during a flight in an Army airplane in the Mediterranean area while on a special mission for the Office of the Secretary of War. Since February, 1941, Dr. Smith has been associated with the RCA Laboratories as a research consultant.

DR. ROBERT PENQUITE, of the Oklahoma Agricultural and Mechanical College, has been appointed associate professor of poultry husbandry at Iowa State College.

ALASTAIR WORDEN, a member of the staff of the Institute of Animal Pathology at the University of Cambridge, has been appointed to the research professorship in animal health recently endowed by Lord Milford at the University College of Wales, Aberystwyth, to investigate the health and productivity of livestock with special reference to human nutrition.

DR. R. E. LANE, who has been lecturer in factory hygiene and lecturer in medicine at the University of Manchester, has been appointed to the chair of industrial health, for the establishment of which the Nuffield Foundation lately made a grant of £70,000. He is expected to take up his new work next September.

THE British Medical Research Council has appointed Dr. A. A. Miles, professor of bacteriology at University College Hospital Medical School, to their staff at the National Institute for Medical Research as from October 1, with a view to his becoming director of the Department of Biological Standards on the retirement next year of Sir Percival Hartley, F.R.S.

DR. J. R. VAN PELT, JR., until recently technical director of the Museum of Science and Industry, Chicago, has joined the staff of the Battelle Memorial Institute at Columbus, Ohio, as head of the program of research education.

DR. PAUL E. KLOPSTEG, director of research at the Technological Institute of Northwestern University, has been reelected chairman of the governing board of the American Institute of Physics. This is Dr. Klopsteg's fifth consecutive term. The previous incumbents of the office were Dean John T. Tate, of the University of Minnesota, and President Karl T. Compton, of the Massachusetts Institute of Technology.

SIR JOHN BOYD ORR has tendered his resignation from the directorship of the Rowett Research Institute after holding that post since its foundation, in which he took a prominent part. Under his direction the Rowett Institute became an important research center for the investigation of problems relating nutrition to agriculture.

DR. E. C. STAKMAN, chief of the Division of Plant Pathology and Botany of the Department of Agriculture of the University of Minnesota, spoke on February 12 before the Plant Institute of the Ohio State University on "The Genetics of Plant Pathogens." At a dinner held at the Faculty Club, he led a discussion on the demands of the post-war economy and the changing status of scientific research. On the following day he spoke on "Improvement in Agriculture in Mexico." His visit was sponsored by the graduate school of the university.

DR. VICTOR LOPEZ, director of the Geological Survey of Venezuela, presented on March 12 an illustrated lecture before the faculty and students of the department of geology of Columbia University and officials from mining and petroleum companies with headquarters in New York City. He described particularly those geological features which apply to phases of mineral production other than petroleum.

LECTURES before the American Institute of Chemists were given on March 20 by Dr. E. H. Northey, assistant director of research of the Calco Chemical Division of the American Cyanamid Company, on "The Chemistry of the Sulfa Drugs," and by Dr. Walter Modell, of the department of pharmacology of Cornell University Medical College, on "The Therapeutic Implications of the Sulfa Drugs and Penicillin."

DR. GEORGE J. HEUER, professor of surgery at Cornell University Medical College, New York, gave on February 20 the eighth Roger S. Morris Memorial Lecture at the College of Medicine of the University of Cincinnati. He spoke on "The Surgical Treatment of Chronic Constrictive Pericarditis."

DR. GEORGE D. SCARSETH, director of research for the American Farm Research Association, who has been associated for many years with research problems vital to agriculture in Central America, addressed on February 15 the Biology Club of the Ohio State University. His topic was "The Control of the Panama Disease of Bananas."

AT a meeting of the council of the American Mathematical Society, held on February 24 at Columbia University, it was voted unanimously to cancel the meetings of the society scheduled for April 27 and 28 in New York City and Chicago. No action was taken by the council regarding the 1945 summer meeting which has been scheduled for June 24 and 25 in Montreal, at the close of the Canadian Mathematical Congress. It is hoped that conditions will be such that it will be possible for the society to take part.

CANCELLATION of the thirty-sixth annual meeting of the American Oil Chemists' Society, which was to have been held in New Orleans on May 9, 10 and 11, has been announced by Dr. Klare S. Markley, president of the society. This action was taken in order to cooperate with the Office of Defense Transportation.

AT the annual meeting of the Texas Society of Pathologists in Dallas, which was held on January 28, it was voted unanimously to become affiliated with the Texas Academy of Science, which is in turn affiliated with the American Association for the Advancement of Science.

THE New York Association of Teachers of the Biological Sciences has announced the founding of an annual High School Congress of Biology in memory of the late Paul B. Mann, who left a fund to advance the cause of scientific thinking among high-school students. The first congress will assemble on May 19 at the American Museum of Natural History. Students in the senior high schools are invited to present reports of research work in biology.

A COMMITTEE of representatives of several chemical and pharmaceutical concerns to raise $500,000 for the enlargement of the library of the New York Academy of Medicine has been organized with Carleton H. Palmer as chairman. The fund would permit construction of a nine-floor addition to the stack room, which would increase the capacity to 374,000 volumes. It would also provide for a new catalogue of 2,800,000 cards, and improved handling, delivery, photostating and bibliographical service.

THE U. S. Public Health Service, in cooperation with the National Foundation for Infantile Paralysis offers graduate fellowships for work in public health to men and women between the ages of 22 and 40 who are citizens of the United States and who hold a bachelor's degree from a recognized college or university. Fellowships will lead to a master's degree in public health. The twelve months' training period will consist of nine months in the School of Public Health at the University of North Carolina, Yale University or the University of Michigan and three months' field experience in community health education under supervision. Applicants must meet the requirements for admission to the schools of public health. Training in science, sociology, education and psychology, plus experience working with people, are desirable prerequisites. Application forms may be obtained from the Surgeon General, U. S. Public Health Service, Washington 14, D. C., and must be returned not later than June 1.

THE New York Heart Association is making a campaign to raise $150,000 to be used to develop a competent staff of field workers, to establish new headquarters and to inaugurate new projects. Dr. Edward P. Maynard, Jr., president of the association, has his headquarters at the New York Academy of Medicine.

A GROUP of mineralogists has formed a committee for the restoration of the Liége mineral collection. The council of the Mineralogical Society of America will sponsor the project, and has appointed Dr. Charles Palache, professor of mineralogy, emeritus, of Harvard University, chairman of the Continental Committee, which will coordinate the work of local committees. Funds for the shipment to the University of Liége of the new collection have been provided by the Belgian-American Educational Foundation.

DISCUSSION

THE DEMOGRAPHIC DILEMMA

PROFESSOR MATHER in his discussion of "The Needs of Man"[1] assumes that because the potential resources of the world are sufficient for a considerably larger world population, we need only the proper economic organization to provide the needs of all. His lack of realism in dealing with problems of agriculture and of population growth does little to clarify the demographic problems and only obscures the major issues.

In his book "Enough and to Spare"[2] Professor Mather states that "the gloomy prediction of Malthus does not now apply and, if present trends continue, never will apply to man." The fact is that most of the human race is now living in Malthusian equilibrium, with high birth rates nearly balanced by high death rates. Only a relatively small proportion of the world's population has been able to escape the consequences of the Malthusian Law.

The modern Western nations were able to escape excessive population pressure by industrialization, migration and control of the birth rate. Their populations are becoming stabilized in accord with their resources. The transition from a high birth rate and a high death rate culture to a low birth rate and a low death rate culture was made only under exceptionally favorable circumstances. These countries were not densely populated in respect to potential agricultural resources, vast areas of land were open

[1] K. F. Mather, SCIENCE, 101: 198–200, 1945.
[2] K. F. Mather, "Enough and to Spare." New York: Harper and Bros., 1944.

for colonization, and they had no competition in industrial development. Yet during this transition the populations increased several fold before living standards became sufficiently high to insure low birth rates and low death rates.

Can the Eastern nations make this transition without analogous growth; or, if not, can they support two to four times their present populations at sufficiently high standards to effect a stabilized population? The experience of Japan indicates that they can not. Between 1870 and 1940 the population of Japan increased from about 30 millions to more than 70 millions and is still growing rapidly. "If the same situation is to occur in the great overcrowded regions of the Asiatic mainland, the race between the expansion of economic opportunity and the accelerated population growth produced by mortality control would seem to be hopeless."[3]

Most of Asia is densely populated in relation to agricultural resources. Professor Mather believes that the Asiatic mainland could support much larger populations because Java is able to maintain a larger number of inhabitants per acre of arable soil. But Java is a region of heavy rainfall and exceptionally fertile soil and her people live little above subsistence levels. The problem is not one of mere subsistence, but the maintenance of a reasonably high standard of living which is essential for the control of the birth rate.

In suggesting mass migration from Asia to Australia and Africa, Professor Mather seems to assume that this solution would be effective if political and socio-economic obstacles could be overcome. The annual excess of births over deaths in India alone is 5 million. If 5 million Indians were moved to Australia each year that country would have all the people it could adequately support in less than five years. Such mass migration would not relieve population pressure in India, and unless the emigrants were absorbed at a relatively high standard of living they would soon create severe population pressure in Australia because of their high birth rates. In the words of Dr. Notestein[3] "emigration will not check growth in the most important areas of population pressure [India, China, Java, Egypt] at the present stage of their demographic evolution. It would be unfortunate to waste the open spaces of the world in a fashion that could only intensify future problems of adjustment."

Industrialization and emigration could relieve population pressure only to the extent that such measures would result in a reduction in the birth rate. In the words of Dr. W. S. Thompson, "There can be no rational hope of a decent life for all mankind if birth rates remain at more than about one-third of the physiological maximum in any considerable part of the world's population."[4] If birth rates in India could be maintained at present levels and death rates maintained at English levels there would be more than 10 billion Indians at the end of another 100 years—five times the present population of the world and three times the number that the entire world could adequately support.

In his book[2] Professor Mather maintains that declining birth rates are a natural consequence of man's evolution and "are due as much to physical factors of the human body as to mental attitudes toward the bearing and rearing of children." He concludes that the Oriental peoples are now entering this evolutionary stage and that declining birth rates will automatically follow. There is no biological evidence to support such a conclusion. Low birth rates of the Western nations are due to the practice of contraception, aided by increased age of marriage and the practice of abortion, and to practically nothing else.[5]

People of all lands who live at little more than subsistence levels breed with no consideration of economic or social consequences. There is some evidence that the Orientals may accept contraception at lower economic levels than do the people of the Western world, but they too have taboos and traditions which will check the diffusion of birth control patterns.

The necessary industrial and demographic evolution can not be achieved without assistance, but the modern Western nations can not promote such evolution simultaneously in all the backward areas of the world. The dominant powers will come out of this war with their own problems of reconstruction, and only the United States will have her industries intact. Aid should be concentrated where there is reasonable hope for success. Many of our good neighbors to the south are growing rapidly and should be industrialized while there is still ample room for the inevitable expansion of population during the transition. The Philippine Islands also should have a high priority. India is the last country which should be included because there is so little hope for success.

It serves no useful purpose to overestimate the world's resources, our ability to increase agricultural production and our capacity to modernize the entire world. There is no justification for denying the validity of the Malthusian Law and no excuse for misrepresenting the biological factors in the control of the birth rate. Optimism based largely upon pious hopes can lead only to greater difficulties in the solution of demographic problems.

KARL SAX

HARVARD UNIVERSITY

[3] F. W. Notestein, *et al.*, "Demographic Studies of Selected Areas of Rapid Growth." New York: Milbank Memorial Fund. 1944.

[4] W. S. Thompson, "Plenty of People." Lancaster, Pa.: The Jaques Cattell Press. 1944.

[5] R. Pearl, "The Natural History of Population." New York: The Oxford Press. 1939.

ESTERASOPENIC AND ESTERASOPLENIC PERIPHERAL NERVE TERMINATIONS

DALE[1] simplified our thinking on function in the peripheral nervous system when he classified the peripheral nerve fibers in two groups, cholinergic and adrenergic. He pointed out that all the nerve fibers leaving the central nervous system are cholinergic, as are also the parasympathetic postganglionics and a few of the sympathetic postganglionics. Most of the sympathetic postganglionics, however, are adrenergic. Dale[2] had pointed out earlier that acetylcholine has two types of actions, the so-called "muscarinic" and "nicotinic" actions in which it mimics the corresponding drugs. In its "muscarinic" action, acetylcholine reproduces the peripheral effects of parasympathetic nerve stimulation, effects produced with low concentrations of acetylcholine and readily abolished by atropine. When the "muscarinic" effects have been abolished by atropine, then the "nicotinic" action becomes apparent as an intense stimulation of all autonomic ganglion cells. Skeletal muscle shows the "nicotinic" effects of acetylcholine even in those rare instances in which it receives a parasympathetic postganglionic innervation. Larger doses of acetylcholine are required to evoke the "nicotinic" effects and these effects appeared to be unaffected by atropine.

It is possible that the differences in acetylcholine concentrations required to elicit the "muscarinic" and "nicotinic" effects may be due in part to differences in cholinesterase concentrations at the respective terminations. High cholinesterase concentrations have been demonstrated by eserine potentiation of acetylcholine at autonomic preganglionic and voluntary motor termination where the "nicotinic" effects of acetylcholine are seen and where atropine is relatively ineffective. Eserine potentiations of the "muscarinic" effects of acetylcholine also have been frequently reported, but in these experiments no attempt was made to differentiate between potentiation due to cholinesterase generally distributed through the tissues and that specifically concentrated at the nerve terminations. This factor was controlled in experiments on the sphincter pupillae of small salamanders[3] and turtles.[4] The eyes were excised and all possible extraneous tissues removed, leaving the iris diaphragm, a supporting rim of sclera and the ciliary body. There was very little tissue covering the sphincter muscle in the thin free margin of the irises of these small eyes. The sphincters of both eyes receive a parasympathetic postganglionic innervation.

[1] H. H. Dale, *Jour. Physiol.*, 80: 10–11, 1933.
[2] *Idem, Jour. Pharmacol. and Exp. Therap.*, 6: 147–190, 1914.
[3] P. B. Armstrong, *Jour. Cell. and Comp. Physiol.*, 20: 47–53, 1942.
[4] *Idem, Jour. Cell. and Comp. Physiol.*, 22: 1–19, 1943.

The sphincter pupillae of the turtle, which is striated muscle, has an acetylcholine threshold of one in one million which is potentiated a hundredfold by eserine, indicating relatively high concentrations of cholinesterase at its nerve terminations. Relatively high concentrations of atropine are required to reduce the pupillary constriction to acetylcholine. These findings are characteristic of the "nicotinic" action of acetylcholine. The sphincter pupillae of the salamander, which is composed of smooth muscle, has an acetylcholine threshold of about one part in one billion. Eserine does not potentiate the pupillary constriction resulting from the application of acetylcholine, so there is no demonstrable cholinesterase at its nerve terminations. Atropine in relatively low concentrations reduces or completely abolishes acetylcholine constriction. The threshold to acetylcholine and the great effectiveness of atropine are characteristic of the "muscarinic" action of acetylcholine.

It is suggested that there are two types of peripheral cholinergic nerve fibers, those at whose terminations there are relatively high concentrations of cholinesterase and those at which cholinesterase is lacking or present in only non-demonstrable concentrations. These might be termed respectively esterasoplenic and esterasopenic terminations. The generality of this classification can be definitely established only by additional work on other cholinergic postganglionic terminations. One should not overlook the possibility that there may be in some organs, which show both acetylcholine effects, both types of cholinergic terminations.

PHILIP B. ARMSTRONG
COLLEGE OF MEDICINE,
SYRACUSE UNIVERSITY

ON DIRECT VISION CHARACTERISTICS OF SPOTS PRODUCING TERRESTRIAL MAGNETIC PHENOMENA

IT is well known that the transit of a large group of sunspots may be followed by aurorae and disturbances in the earth's magnetic field; but this is not invariably the rule. Occasionally smaller groups may cause more violent disturbances than larger ones, and sometimes no effect whatever is noticed. Therefore not all spots will produce terrestrial electromagnetic effects; but, unless one knows what to look for, direct visual examination will reveal no essential difference between those spots which do and those which do not. However, the writer has worked out a method which appears to be very satisfactory.

In 1850 Lamont at Munich, with insufficient data, discovered that the mean variation of the diurnal magnetic oscillation showed a period of close to 10.33 years. This was followed in 1851 by Schwabe's announcement that the sunspots are periodic.

Based on 25 years of observations, Schwabe calculated a mean period, from maximum to maximum, of about 10 years; which was not far from the presently received value of 11.11 years. Wolf, Sabine and Gautier immediately recognized the coincidence of Schwabe's spot cycle with the magnetic cycle of Lamont. Subsequent work confirmed a general correspondence; and Loomis showed that there was a direct relation between the incidence of aurorae and the incidence of sunspots.

It was believed at first that the spots alone were in some manner responsible for terrestrial magnetic effects; but in 1859 Carrington and Hodgson, observing simultaneously and independently, saw two brilliant floccular masses suddenly appear at the edge of an umbra over which they passed before vanishing. The fact that these cloud-like forms passed over the umbra, without altering it sensibly in any way, showed them to be at a considerable elevation above it and probably in the chromosphere. This classical appearance was followed the same night by an extraordinarily brilliant aurora and an intense magnetic storm.

In 1872 Young, observing the chromosphere spectroscopically, noted a jet eruption which was followed by an almost instantaneous and violent oscillation of the needle; which caused him to believe that the disturbing emanation was propagated with the speed of light. This, however, was an exceptional case. Normally the magnetic manifestations occur about 26 hours after transit (Abetti), although there are great variations on either side of the mean.

Now it is generally believed that electrons, ionized atoms and "corpuscles," derived from the sun, all contribute to the production of terrestrial aurorae and magnetic disturbances. Since the velocity of escape for the sun is 383 miles per second, something other than the eruptive currents in spots is suggested as the probable source of the currents reaching the earth; and velocities approaching the critical velocity for the sun are more apt to be found in the prominences.

Pettit showed that the maximum mean velocity of a group of prominences studied by him was 94.86 miles per second, with several showing a velocity as high as 248 miles per second. Moreover, the velocity of a prominence is not entirely the result of a simple eruptive force. Bobrovnikoff demonstrated that the repulsive force acting on prominences *increased* with the mean distance of the prominence above the photosphere. Radiation pressure was therefore brought into the picture, and Milne showed that the limiting velocity of escape for an atom held in suspension in the chromosphere is 992 miles per second (1,600 km/sec). At such a speed atoms would be capable of penetrating the earth's atmosphere to a sufficient depth to account for auroral manifestations.

It is therefore to eruptions, rather than to the spots per se, that one should look for the source of the ionized atoms, electrons, etc., which disturb the earth's magnetic field and produce aurorae. This seems to have been suggested first by Tacchini, and was later confirmed by Hale, followed by others.

This being so, a means is at once afforded the telescopic observer for determining by direct vision which of any spots will be likely to produce disturbances. In a recent paper[1] the writer called attention to the possibility of studying the distribution and movements of flocculi, in the immediate neighborhood of a spot group, by direct vision observations of the apparent alterations in the penumbrae of the spots. Now frequent and rapid movements of flocculi over the penumbrae, manifested by great apparent changes in the latter, give evidence of profound eruptive disturbances in the chromosphere. Thus a spot group which may not be attended by other visible features, such as faculae, will nevertheless betray associated chromospheric activity. Such notably was the great group of February 25–March 1, 1942, which was followed by a violent magnetic storm about 12 h after transit.

But flocculi are frequently associated with and in some cases may be only high level extensions of faculae. Hence faculae may also be used to indicate probable electromagnetic disturbances on the earth. Since faculae are considerably brighter because higher than the photosphere (shown by the fact that they are conspicuous near the limbs but are almost always invisible at the center of the disc), the radiation pressure from such areas is correspondingly greater and therefore apt to be the source of a current of electrons or ionized atoms. Moreover a region of intense facular disturbances is likely also to be associated with active prominences. In general, therefore, any group associated with extensive faculae is also likely to produce aurorae and magnetic effects.

This was well illustrated by the magnetic disturbances following the transit of the large group on December 13, 1944. This group was associated with an extensive area of faculae, bright enough to be visible when three days from the following limb. On December 19, when this group was approaching the preceding limb, the writer observed two brilliant, cloud-like masses following it which were inclined to one another by almost 90°. These objects resembled in shape strato-cumulus rolls and were floccular in nature; they were associated with ordinary faculae.

The writer finds from personal observations, extending back to 1926, that such direct vision phe-

[1] SCIENCE, March 3, 1944; p. 180.

nomena are reliable indications of probable magnetic disturbances to be expected before or after transit; although they do not provide a measure of the probable intensity. They are therefore easily observed phenomena accessible to students who may lack elaborate accessory equipment, and are especially suitable to demonstration in small schools or colleges where the astronomical equipment may be limited to direct vision instruments.

JAMES C. BARTLETT, JR.,
Chairman, Astronomical Section
AMERICAN INTERNATIONAL ACADEMY, INC.,
BALTIMORE, MD.

ELECTRONICS AS A POSSIBLE AID IN THE STUDY OF BIRD FLIGHT AND MIGRATION

SINCE the veil of secrecy which so long surrounded electronics, and particularly the functioning of radar equipment, has been partially lifted, I am at liberty to tell of certain observations made by an ornithologist friend who is a naval officer on duty in the Pacific. He states that on numerous occasions the radar equipment in use on his vessel has detected the presence of good-sized birds, albatrosses, man-o'-war birds, etc., at distances as great as five or six thousand yards. When distances as shown by instrument were checked against ocular estimates of distances of approaching birds from the vessel it was found that the two figures were in close agreement.

In the light of these observations I wish to record that we have discussed, and expect to carry out, experimental work on the study of bird flight and bird migration by means of radar equipment, when such equipment is made available for private use. We have tentatively selected a West Virginia mountain-top as a site for the work. Here there is an absence of obstructions, coupled with a good movement of migrating birds, particularly raptors.

We plan to attempt the use of this equipment in determining the speed of flight of birds large enough to produce a signal on our equipment, the height of flying birds, and the detection, and speed and height of flight, of night migrants. In some cases (wild geese, for example) it may be possible to make reasonably accurate identifications of passing night migrants. It seems likely that electronics holds the key to much more detailed information regarding bird flight than any which we now have.

MAURICE BROOKS
WEST VIRGINIA UNIVERSITY

A TERTIARY RIVER

WITHIN recent years, considerable work has been done by geologists, in tracing the course of a large pre-glacial stream, called by W. G. Tight, the Teays River. This stream had its source near the eastern escarpment of the Blue Ridge, at the edge of the Piedmont Plateau in North Carolina and Virginia. In addition to the waters of the New-Kanawha system, the Teays River received the major portion of the drainage from an area including one half to two thirds of Ohio, a large part of Indiana, Illinois and northern Kentucky. The Teays River, after passing through the abandoned valley of that name, extended from a point near St. Albans to Huntington, W. Va., passing across Ohio in a northwesterly direction; its valley, buried beneath the glacial drift, extends from Chillicothe, Ohio, to the border of Indiana, not far from the St. Marys Reservoir, in Ohio. From there its course is westward across northern Indiana, to the eastern border of Illinois, where it continues in a westerly direction across the state into the bedrock valley of Illinois River. From Chillicothe, Ohio, westward, the course of the buried Teays has been determined by the study of well records by Ver Steeg in Ohio, Fidlar in Indiana and Horberg in Illinois. These studies indicate that the Teays River had many large tributaries. All the indications point to the fact that this stream was in the mature stage and drained a maturely dissected region in the Appalachian area. Well records, in Ohio, indicate that this stream occupied a broad, deep valley, with rather steep sides, similar to the valley from St. Albans, W. Va., to Chillicothe, Ohio. Farther west, in Illinois, the buried Teays valley becomes shallower and broader; according to Leland Horberg, it has a width of five miles in central Piatt County, about fifteen miles in De Witt County, Illinois, and an average depth of about 200 feet. This great stream, rising in the Piedmont, flowing across the entire Appalachian area, through the steep-walled Kanawha Valley and across the states of Ohio, Indiana and Illinois, is estimated to have been at least 800 miles long, and to have rivaled some of the larger streams on the continent.

During the Pleistocene ice-age, it is believed that the Teays River in Ohio was dammed by the Kansan or pre-Kansan ice-sheet and great ponded stretches of slack-water flooded large areas of southeastern Ohio. Thick deposits of slack-water silts, now at elevations of 860 feet, were laid down. It may be that the large glacial erratics found on the hills in Kentucky, at altitudes as high as 1,000 feet, were rafted to their present position by icebergs which floated on the deep waters of the ponded expanse.

The Teays River valley is believed by E. A. Transeau, the botanist, to have been a highway along which the Tertiary flora migrated from the Piedmont and southern Appalachians into southeastern Ohio.

KARL VER STEEG
WOOSTER, OHIO

SCIENTIFIC BOOKS

PLANT GEOGRAPHY

Foundations of Plant Geography. By STANLEY A. CAIN. xiv + 556 pp. New York: Harper and Brothers. 1944. Price, $5.00.

ONE of the great difficulties in present-day science is to get the immense amount of fact, deduction and theory concerning a specific subject into sufficiently compact form so that the interested individual can at least get some idea of the whole picture. This Dr. Cain has done for dynamic plant geography—a geography mainly concerned with how and why a plant got where it is rather than just where it is. This book is in no sense a conventional plant geography. Habitats, ecological or geographical, of plant groups of almost any size or kind, are given scant attention. In Dr. Cain's own words, the book is "an effort to survey the related fields of science for concepts and working methods which are useful in an interpretation of the phenomena of plant distribution. Many of the materials are from the fields of paleontology, taxonomy, evolution, genetics and cytology. I have sought to cut the hedgerows between these fields of science, and to discover, for myself at least, some of the significance which one field has for another."

In cutting the hedgerows, Dr. Cain has organized his material into thirty chapters, each in most cases epitomized in italics at the start, followed by discussion and factual illustration, often ending with the author's criticism for or against. These chapters are grouped into five parts: introduction, paleoecology, areography, evolution and plant geography, significance of polyploidy in plant geography. There is a very much needed glossary, since the terminology used in some cases reminds one of certain English-language novels full of French-language expressions. One might be critical here, for the author, figuratively speaking, does not always call a spade a spade, but refers to it as a geotome.

There is a "Literature Cited" list of 720 titles, mostly of recent vintage, covering many biological fields. Among the striking omissions are references to R. E. Cleland's work on *Oenothera* and to the works of Charles Elton on the importance of population size as an evolutionary factor. There is an excellent index.

In reviewing a work of this type, there is a great temptation to discuss many of the chapters, especially those involving subject-matter with which the reviewer is most familiar, but space restrains him. Among the most interesting chapters are "Certain Aspects of the History of Cenozoic Vegetation of Western America," "Species Senescence," "Causes of Species Stability," and "Rate of Evolution and Speciation." All the chapters are thought-provoking, written for those who question and not for those who just swallow. The language is technical and, outside of outline maps and diagrams, there are no illustrations.

The author in dealing with polyploidy, diploidy and haploidy is apparently unaware of the use of n and $2n$ in speaking of haploids and diploids in the generation sense. He suggests the use of g for gametophytic or haploid and S for sporophytic or diploid individuals.

The title of the book, for many people, would be misleading; it is primarily a book on evolution, to be classed alongside Julian Huxley's "Evolution; the Modern Synthesis," and it ought to be of great interest to any one properly backgrounded who is seriously concerned with the broad problems of evolution.

ORLAND E. WHITE
THE RLANDY EXPERIMENTAL FARM,
UNIVERSITY OF VIRGINIA,
BOYCE & CHARLOTTESVILLE, VIRGINIA

ELECTROTHERAPY

Technic of Electrotherapy. By STAFFORD L. OSBORNE and HAROLD J. HOLMQUEST. C. C Thomas, Springfield, Illinois, 1944. Price $7.50.

ELECTROTHERAPEUTIC measures, like many procedures employed in the practice of physical medicine, can be used successfully only when intelligently prescribed and appropriately applied. Unhappily, the practice of physical medicine has sometimes fallen short of its great potential because it has been applied empirically without basic knowledge of physics and physiology. Fortunately, physical medicine is now attracting the interests and activities of men who bring to it a background of training and experience in physical sciences and physiology. This book provides an excellent example of this development. The book represents collaborative efforts of two experienced investigators and teachers in the fields of applied physics and applied physiology. Both authors have had considerable experience in the special field of electrotherapy, having conducted courses for a number of years at Northwestern University Medical School.

According to the authors, their book is regarded as a supplementary text for students of physical medicine. This limitation to a supplementary role represents a modest appraisal for a book which is sufficiently comprehensive to be described as a reference manual on the principles as well as the techniques of

electrotherapy. It is addressed to the widely varied interests of technicians, medical students and physicians. It meets the several requirements of these groups by providing sound physical and physiologic rationale for electrotherapeutic measures in terms which are neither too profound for the less experienced nor too elementary for the more experienced groups. This difficult matter has been accomplished in part by a division of text. For students who are well grounded in science and who desire comprehensive information regarding fundamentals of electrotherapy, some physical and mathematical data are presented in footnotes. For the students who are less well grounded in science and who desire more streamlined information, the general text, illustrated with a minimum of mathematical formula, is fully satisfactory.

Although bound in one volume, the material has been so arranged that it actually provides four books in one. Major divisions are devoted to the effects and technical application of direct current, electrical muscle stimulation and radiation and high frequency current. Each of these sections is developed with a fixed pattern and with sufficient detail to stand alone. Each division includes a description of theoretical as well as instrumental aspects of electrical phenomena. In many instances, illustrative experiments are described. The influence of each type of electrical energy on man is also indicated by detailed experiments. Comprehensive pictorial and textual descriptions of apparatus currently used in practice are presented. Descriptions of clinical conditions amenable to electrotherapeutic measures are presented in terms of physiological effects induced.

The book is profusely illustrated with diagrams and photographs. The diagrams are well chosen and informative. In contrast, some of the illustrations of apparatus have not been so critically selected and reproduced. These apparent faults are partly due to the use of plates borrowed from previous publications and to failure in eliminating material that is repetitive or unnecessary. In these respects, the book suffers from the minor faults which are common in first editions. None of these detracts from the inherent worth of the book as a whole. There is some lack of uniformity in the style of illustrations, but this may be justified at present as a measure of economy.

The presentation of precise data on the changes in physiology induced by physical agents fills a long-felt need in physical medicine. The summaries of such data appearing in this book set a standard which might well be followed in other branches of physical medicine.

"The Technic of Electrotherapy" can be commended to all groups of students of physical medicine, including technicians and physicians. That technicians should be familiar with the principles of the underlying procedures which they apply is widely appreciated. It is equally evident that the results of prescriptions for electrotherapeutic measures are more successful when written by physicians who are familiar with the physical nature and physiologic influence in the procedures recommended. It is therefore to be hoped that the book will find its way into the hands of the general practitioner as well as into the hands of the specialist in physical medicine. This contribution to the literature of physical medicine provides a significant step toward the establishment of physical medicine in its proper place among medical specialties.

RALPH PEMBERTON
UNIVERSITY OF PENNSYLVANIA

REPORTS

PROGRAM OF THE INSTITUTE OF RADIO ENGINEERS

THE Institute of Radio Engineers, representing the leading radio engineers, is fostering an extensive program for aiding postwar activities. SCIENCE has received the following report in regard to the plans of the institute:

The most remarkable aspects of the growth of the radio industry have been not only its impact upon activities in many other fields, but on the great number of new industries that have been created from the developments of its engineers. The scope of some of these have been so far afield from that which is usually considered to be "radio" that a general term has become popular to describe these miscellaneous applications of radio principles—"electronics." It is interesting to note the scope of this work, as set forth on the cover of the *Proceedings* of the Institute of Radio Engineers: "Radio communication, sound broadcasting, television, marine and aerial guidance, engineering education, power and manufacturing, applications of radio-and-electronic technique, industrial electronic control and processes, tubes, electron optics, medical electrical research and applications, radio-frequency measurements, sound and picture electrical recording and reproduction."

Many of these fields became prominent before the war. However, the trend to electronic methods utilizing war-born developments will revolutionize many other industries and start new ones previously unknown.

The factor which will have a great influence in get-

ting these projects under way as readily as possible will be the dissemination of the information relative to all phases of electronic development to radio engineers. The fact that the art is highly specialized together with the security rules that have been in force have narrowed down the activities in each individual's field to but a few specialists. But the number of these projects is large and a far-reaching guided program of cooperation is needed to make such developments of greatest utility to a world-wide public. This matter has concerned the industry itself to no small degree.

The promotion of engineering standards will provide all engineers with a common set of terms and test methods. The work of arranging the preparation and publishing of the details of hundreds of application principles (many of them now classified as military secrets) is another phase of this work. Giving greater service to engineers in more remote sections through enlarged and more numerous branch sections is a third. Providing information service to those engineers of the required quality in such a highly technical and widely diversified field requires not only additions to the staff of men having the specific qualities in training and experience to handle the jobs, but also adequate equipment facilities so that their help can be most effectively utilized. All in all, the plans include the following activities: publication of important papers with less delay, post-war publication of a large amount of material now held secret, more adequate publication coverage of the subdivisions of radio-and-electronic interest, publication of a handbook, annual publication of a Year Book, better correspondence service with the sections, program aid to sections, section aid by traveling lectureships, formation and professional direction of semi-autonomous specialist groups in the larger sections, integration of a conference program reaching all parts of the country, proper organization of college activities and other educational work, full-time supervision of standardization activity, creation and housing of a technical library, establishment of employment and placement bureau, activity in legislative matters, additional liaison work with other societies, Government and engineering bodies.

The nucleus of this program will be the concentration of all activities undertaken by the enlarged institute, in a new headquarters building, which will become a center for the promotion of all related activities. In view of the most remarkable strides that have been made by the engineers of this organization in giving to this war the most scientific devices ever developed by any country, this building will have international importance, because the peace-time products of the same group will have world-wide value.

Already the impact of this project has been shown by the nationwide response of both the members and the industrial organizations who foresee the significance of the work, in providing the financial backing of such a headquarters building to insure adequate handling of the needed activities. The response is also remarkable as to the number of new applications for membership from the engineers and research workers in this profession who see in this program the most practical way of getting "educated" as to all the advances made by others during the past five years.

In this expansion, the institute will have the same democratic status as it has had during more than thirty years of its existence. It is the broad-minded cooperation by the members themselves that has heretofore made the publication of all important developments possible, and the work of administering the affairs has always been done by officers who have been elected from those practicing the profession and knowing its problems.

The enthusiasm evident from the response to the call for help on this building project has been such that assurance can be given that it will go through, and work is progressing to the next steps in the plan, that of the procurement and outfitting a suitable structure. The directors are reserving the right to join with other engineering and scientific societies in a common building program if that seems advantageous.

SPECIAL ARTICLES

THE PRECIPITATION OF PURIFIED CONCENTRATED INFLUENZA VIRUS AND VACCINE ON CALCIUM PHOSPHATE[1]

DURING a study[2] of methods useful in the concentration and purification of influenza virus, data on a method involving the precipitation of virus on calcium phosphate[3] were not presented because in preliminary experiments effective purification and concentration of virus were not achieved and because the method appeared impractical for the preparation of virus on a large scale. However in view of the finding by Salk[4] that the precipitation on calcium phos-

[1] The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and The Rockefeller Institute for Medical Research.

[2] W. M. Stanley, *Jour. Exp. Med.*, 79: 255, 1944.

[3] J. E. Salk, *Proc. Soc. Exp. Biol. and Med.*, 46: 709, 1941.

phate of formalinized influenza virus from allantoic fluid yields a product possessing an enhanced immunizing potency, it appeared desirable to present data on the nature of this precipitate. It also appeared desirable to study the precipitation of purified, concentrated influenza virus[5, 6] and vaccine[7] on calcium phosphate with a view to the use of suspensions of such preparations for purposes of immunization.

In order to establish the amounts of reagents necessary to insure precipitation of essentially all the virus in allantoic fluids, increasing amounts of molar solutions of sodium phosphate, calcium chloride and sodium hydroxide were added to five 100 cc portions of freshly harvested PR8 allantoic fluid. The sodium phosphate buffer at pH 8 was added first to insure the presence of sufficient phosphate ions. The calcium chloride and sodium hydroxide were added simultaneously, dropwise and with stirring. The precipitates were removed by centrifugation in a clinical centrifuge and in order to prevent the mechanical transfer of any of the precipitates the supernatant liquids were decanted through filter paper. The amounts of the reagents used and the analyses on the supernatant fluids are given in Table 1. The

TABLE 1

AMOUNTS OF CHICKEN RED CELL AGGLUTINATING (CCA) ACTIVITY AND NITROGEN PRECIPITATED FROM INFECTIOUS PR8 ALLANTOIC FLUID ON ADDITION OF DIFFERENT AMOUNTS OF CALCIUM CHLORIDE

Volume of reagents used*				Supernatant liquid†				
							Test with	
PR8 allantoic fluid	1 M sodium phosphate pH 8	1 M calcium chloride	1 M sodium hydroxide	CCA activity	Total N	pH	Calcium ions‡	Phosphate ions
cc	cc	cc	cc	units/cc	mg/cc			
100	0.00	0.0	0.0	250	0.68	8.1	+	–
100	0.25	0.5	0.4	197	0.65	8.1	+	–
100	0.50	1.0	0.8	105	0.62	8.3	+	–
100	0.75	1.5	1.2	48	0.60	8.5	+	–
100	1.0	2.0	1.6	10	0.57	8.6	–	–
100	1.5	3.0	2.4	3	0.53	8.7	–	+

* Calcium chloride and sodium hydroxide were added simultaneously, dropwise, with stirring.
† Obtained by 5 minutes centrifugation in a clinical centrifuge followed by filtration through filter paper.
‡ + indicates precipitate, hence excess of phosphate ions in supernatant fluid; – indicates no precipitate.

chicken red cell agglutinating (CCA) activity was used as a quantitative measure of influenza virus,[8, 9] but in all cases in which it was also followed by means of nitrogen determinations the results were essentially identical. It can be seen from Table 1 that about 2 cc of 1 M calcium chloride were required to precipitate about 95 per cent. of the CCA activity and that this was accompanied by the precipitation of 0.11 mg of nitrogen per cc of allantoic fluid. With some allantoic fluids as little as 1.5 cc of molar calcium chloride were found sufficient to precipitate 95 per cent. or more of the CCA activity from 100 cc of fluid.

The distribution of CCA activity, total nitrogen and protein nitrogen on treatment of formalized PR8 allantoic fluid with sufficient calcium chloride to precipitate over 95 per cent. of the virus was determined in order to secure information concerning the nature of the precipitate that is obtained. The amounts of reagents and solutions used for the formation and washing of the precipitates are given in Table 2. It can be seen from Table 2 that the washed precipitate contained 0.03 mg of total nitrogen per cc of allantoic fluid and, since this can be presumed to represent protein nitrogen, the precipitates contained about 0.3 mg of protein per cc of allantoic fluid. Infectious allantoic fluid is known[7] to contain about 0.1 mg of influenza virus protein per cc and since most of the CCA activity originally present in the allantoic fluid was present in the precipitate, the protein contained in the precipitate can be presumed to consist of about

TABLE 2

DISTRIBUTION OF NITROGEN AND CCA ACTIVITY ON FRACTIONATION OF FORMALINIZED PR8 ALLANTOIC FLUID BY CALCIUM PHOSPHATE METHOD

Fraction	Experiment 1*				Experiment 2†			
	Total N	Protein N	CCA activity	pH	Total N	Protein N	CCA activity	pH
	mg/cc	mg/cc	units/cc		mg/cc	mg/cc	units/cc	
Formalinized PR8 allantoic fluid ..	0.70	0.16	300	8.1	0.47	0.10	314	8.2
Supernatant liquid of calcium phosphate precipitate ...	0.62	0.11	16	8.0	0.39	0.02	4	8.1
First wash of precipitate.	0.05	0.02	24	7.6	0.05	0.03	18	7.6
Second wash of precipitate	0.01	0.00	2	7.4	0.01	0.01	1	7.6
Suspension of washed precipitate ...	0.03				0.03			

* 250 cc PR8 allantoic fluid, 0.125 cc formalin, 3 cc 1 M sodium phosphate at pH 8, 3.75 cc 1 M calcium chloride and 3 cc 1 M sodium hydroxide were used. Precipitate was washed twice with 125 cc portions of 0.05 M sodium phosphate at pH 7.6. Data are based on volume of allantoic fluid used as starting material.
† 500 cc PR8 allantoic fluid, 0.25 cc formalin, 15 cc 1 M calcium chloride and 12 cc 1 M sodium hydroxide were used. Precipitate was washed twice with 200 cc portions of 0.05 M sodium phosphate at pH 7.6. Data are based on volume of allantoic fluid used as starting material.

[4] J. E. Salk, SCIENCE, 101: 122, 1945.
[5] M. A. Lauffer and W. M. Stanley, *Jour. Exp. Med.*, 80: 531, 1944.
[6] G. L. Miller, M. A. Lauffer and W. M. Stanley, *Jour. Exp. Med.*, 80: 549, 1944.
[7] W. M. Stanley, *Jour. Exp. Med.*, 81: 193, 1945.
[8] G. K. Hirst, SCIENCE, 94: 22, 1941.
[9] G. L. Miller and W. M. Stanley, *Jour. Exp. Med.*, 79: 185, 1944.

one third virus protein and two thirds non-virus protein. It was found by means of total solids determinations on the washed precipitates from allantoic fluid and on precipitates obtained by the reaction between 1 M calcium chloride and 0.1 M phosphate buffer at pH 7 that essentially all the calcium is precipitated as the diphosphate. Therefore the results indicate that when sufficient 1 M calcium chloride is added to 100 cc of allantoic fluid to precipitate about 95 per cent. or more of the virus, the washed precipitate will consist of about 10 mg of virus protein, about 20 mg of non-virus protein and about 200 to 300 mg of calcium phosphate. The virus-calcium phosphate ratio is about 1 to 25 and this can not be decreased because a reduction in the amount of calcium chloride added would result in a loss of virus. The high virus-calcium phosphate ratio operates effectively to prevent concentration of virus to any great extent. Because of this fact and the fact that the precipitates contain a large amount of non-virus protein the method can not be regarded as efficient for either the concentration or purification of influenza virus present in allantoic fluids.

However, because of Salk's[4] finding that calcium phosphate has an adjuvant effect on formalinized influenza virus, a study was made of the precipitation on calcium phosphate of influenza virus[2] and vaccine[7] purified and concentrated by differential centrifugation. In preliminary experiments with active purified PR8 influenza virus over the concentration range of 0.1 mg to 10 mg of virus protein per cc in 0.1 M phosphate buffer at pH 7 it was found that, regardless of the virus concentration, approximately 5 cc of molar calcium chloride were required per 100 cc of virus solution to precipitate 95 per cent. or more of the virus. This finding was confirmed in experiments with a concentrated purified polyvalent influenza virus vaccine prepared commercially and described in an earlier publication.[7] The results obtained with this vaccine (Table 3) demonstrate that when about 95 per cent. or more of the virus is precipitated, the virus-calcium phosphate ratio is about 1 to 70 when virus is precipitated from a solution containing 0.1 mg per cc, about 1 to 7 when virus is precipitated from a solution containing 1 mg per cc and about 1 to 1 when virus is precipitated from a solution containing 10 mg per cc.

It is necessary to carry out the formation of the calcium phosphate precipitate in the presence of the virus in order to secure effective precipitation of the virus for in an experiment in which 1 mg of virus in 1 cc was added to a suspension of precipitate formed by the addition of 0.3 cc of molar calcium chloride and 0.22 cc of molar sodium hydroxide to 9.0 cc of 0.1 M phosphate buffer at pH 7 about 37 per cent. of the virus was found in the supernatant liquid following centrifugation of the mixture in a clinical centrifuge. In another test in which 10 mg of virus in 1 cc were added to a suspension of precipitate formed by the addition of 0.5 cc of molar calcium chloride and 0.38 cc of molar sodium hydroxide to 9.0 cc of 0.1 M phosphate buffer at pH 7 about 28 per cent. of the virus was found in the supernatant liquid. As indicated by the data in Table 3 the corresponding values, when the precipitate was formed in the presence of virus, were 17.6 and 4.8 per cent., respectively. The fact that the precipitate must be formed in the presence of the virus in order to secure effective precipitation of virus and the fact that over a wide range of virus concentration a given amount of calcium phosphate precipitates out essentially the same percentage of virus are of considerable interest.

Since formalinized influenza virus purified by a single cycle of differential centrifugation can be obtained readily on a large scale[7] at a concentration of about 3 mg per cc it is obvious that such material can be used to prepare virus-calcium phosphate precipitates in which the ratios of virus to calcium phosphate can range from about 1 to 2 to any larger value. If necessary more concentrated virus, which will yield ratios down to 1 to 1, can be obtained. The immunizing potency of different amounts of precipitates containing various virus-calcium phosphate ratios should be determined in order to establish the optimum ratio and the optimum amount of precipitate necessary for the effective immunization of human beings. Since a virus-calcium phosphate ratio less than

TABLE 3

PRECIPITATION OF CONCENTRATED, PURIFIED POLYVALENT INFLUENZA VIRUS VACCINE* ON CALCIUM PHOSPHATE

Concentration of virus materials in 10 cc of solution	Volume of reagents added†		Supernatant liquid‡		
	1 M calcium chloride	1 M sodium hydroxide	CCA units per cc	Test with: Calcium ions§	Test with: Phosphate ions
	cc	cc			
0.1 mg per cc			170	+	–
"	0.2	0.15	72	+	–
"	0.3	0.22	30	+	–
"	0.4	0.30	17	+	–
"	0.5	0.38	11	+	–
1.0 mg per cc			1,700	+	–
"	0.4	0.30	174	+	–
"	0.5	0.38	82	+	–
"	0.6	0.46	38	+	–
10.0 mg per cc			17,000	+	–
"	0.5	0.38	144	+	–
"	1.0	0.77	2	–	+

* Vaccine prepared commercially to contain 10 mg of influenza virus materials per cc in 0.1 M phosphate buffer at pH 7, inactivated with 0.05 per cent. formalin and preserved with 1 : 100,000 phenyl mercuric nitrate. Contains Lee, PR8 and Weiss virus materials in the ratio of 2 : 1 : 1.

† Calcium chloride and sodium hydroxide were added simultaneously, dropwise, with stirring.

‡ Obtained by 5 minutes centrifugation in a clinical centrifuge followed by filtration through filter paper.

§ + indicates precipitate, hence excess of phosphate ions in supernatant fluid; – indicates no precipitate.

about 1 to 25 can not be obtained with allantoic fluid whereas with concentrated virus any ratio down to about 1 to 1 can be obtained, a much more complete study of the adjuvant effect of calcium phosphate on influenza virus vaccines can be made by the use of virus materials concentrated and purified by means of differential centrifugation.

W. M. STANLEY

THE ROCKEFELLER INSTITUTE
FOR MEDICAL RESEARCH,
PRINCETON, N. J.

RECORDING OF SOUNDS PRODUCED BY CERTAIN DISEASE-CARRYING MOSQUITOES

THE destruction of disease-carrying mosquitoes is a problem of the first magnitude. Various methods have been employed such as oiling, draining and the application of larvacides and insecticides. In this connection, the use of D.D.T., both in powder form and as a spray, has been astonishingly effective when used in the field. D.D.T. destroys a variety of insects both harmful and beneficial so that the problem of disturbing the biological balance such as the interference with pollenizing insects, for instance, must be taken into consideration.

When sprayed upon walls of dwellings D.D.T. will repel or kill mosquitoes and other insects for long periods of time. It must not be forgotten, however, that this substance is toxic when ingested. The other methods of mosquito control are often quite expensive and time-consuming.

In order to circumvent these objections, we have approached the problem of mosquito destruction from a somewhat novel angle. It occurred to us that mosquitoes might have characteristic "mating calls." If so, these characteristic sounds, if properly recorded and satisfactorily reproduced, might aid in the attraction of mosquitoes to their death.

We have successfully recorded mosquito sounds which are faintly audible, or completely inaudible to the human ear, and are now able to transmit these sounds, with the end in view of calling specific varieties of mosquitoes to a place of destruction.

The following mosquitoes were employed: *Anopheles quadrimaculatus, Aedes aegypti, Aedes albopictus* and *Culex pipiens.* Colonies of these insects are maintained in the laboratory. The electrical apparatus which is utilized is (1) a microphone, (2) an amplifier of considerable more than usual power, (3) suitable band pass filters and (4) a conventional high quality disk recorder. When the recordings are made, the mosquitoes are placed in a sound-proofed test chamber under conditions of proper temperature and humidity, in order to obtain sensitive recordings under a natural environment.

Certain varieties of mosquitoes such as *Aedes aegypti* have been thought to produce little if any sound. If sounds are produced, they must be outside of the range of human hearing. This we have found to be the case. One may disturb a cage containing 200 or more of this species, yet no audible sounds are heard. One may listen intently in a very quiet room to *Culex pipiens,* but only the very most intense sounds of this species are faintly audible. We have observed that the largest variety of sounds made by this species as well as the others referred to are outside the energy range of normal hearing.

Despite the great variety of sounds, each genus and species have tonal emanations which are so distinctive in character that an experienced observer can not only readily distinguish one genus from another, but with no difficulty at all can also distinguish the males of a species from the females of the same species. Even such closely related species as *Aedes aegypti* and *Aedes albopictus* can be distinguished by sounds alone.

In not a few respects, the sounds of the mosquitoes we have tested are like bird calls. Their variety seems to indicate that they may be in the nature of (a) mating calls, (b) calls warning of danger, (c) calls of anger and other sounds that are similarly functional.

All the sounds that we have recorded to date are in the center of the frequency range of human hearing but far below the energy level required for that purpose. The fundamental tones lie in the range from 250 cycles per second to 1,500 cycles per second. It is interesting to note that all male "voices" so far recorded are much more high pitched than the females. Pitch is a simple means of distinguishing one mosquito sex from another. Female voices contain far more energy than males even when the insects are not in flight.

The most astonishing and important observation of this experiment is that the noise of a single female will cause the males of the same species to burst into an answering chorus. Moreover, when the call of a female is transmitted to two or three males under the circumscribed space of a small test-tube, it has been observed under the microscope that the antennae and hypopygium of the male will turn toward the direction from whence the sound is being transmitted.

Single mosquitoes seemingly do not emanate any sound. Two or more must ordinarily be together before any sounds are generated. This seems to be true regardless of species or of sex. If two mosquitoes of the same sex do not choose to be active, the addition of a mosquito of the opposite sex will often cause activity in the erstwhile silent insects.

In certain mosquitoes, two tones, separated by a

small pitch interval, or often an interval of one half a musical tone, can be produced simultaneously, thereby producing "beats." It is possible that the production of such beats is an aid to the listening insect in determining the direction from which the sound originated.

As far as we can determine at the present time, the sounds seem to be produced by three methods: (1) noises made when the mosquitoes are in flight, (2) the beating of the wings while the insects are at rest and (3) the rubbing of the tarsi against the wing, (4) certain pure bird-like sounds the origin of which we have not been able to determine.

Additional recordings are being made, and as soon as conditions permit, each significant tone will be tested in the laboratory and in the field in order to test its ability to lure the mosquito to some form of destroying mechanism.

In the case of the Anopheles, it may be necessary to make a separate recording for each potentially dangerous species, but if this is necessary it is a simple matter. Possibly this method will be of aid in the destruction of other insects as well as rats and rodents concerned in disease transmission.

We wish to thank Dr. Mark F. Boyd and Dr. Max Theiler, of the Rockefeller Foundation, for their courtesy in supplying us with *Anopheles quadrimaculatus* and *Aedes albopictus* with which we began our colonies. The *Aedes aegypti* were obtained in the South, while Dr. Denis R. A. Wharton captured a wild strain of *Culex pipiens* for us in New Jersey. The technical assistance of Miss Isabella Brogan is greatly appreciated. This study was aided by the American Foundation for Tropical Medicine.

MORTON C. KAHN
WILLIAM CELESTIN
WILLIAM OFFENHAUSER
DEPARTMENT OF PUBLIC HEALTH AND PREVENTIVE MEDICINE,
CORNELL UNIVERSITY MEDICAL COLLEGE,
NEW YORK

THE EFFECT OF PENICILLIN AND CERTAIN SULFA DRUGS ON THE INTRACELLULAR BACTEROIDS OF THE COCKROACH

IT has been well known for many years that certain cells in the fat body of cockroaches contain masses of rod-like microorganisms resembling bacteria in shape. These, known as bacteroids, are present in every individual roach of both sexes and are known to be hereditary in the sense that they migrate into the ovaries and thence into the eggs before these are fully formed. Later they become a part of the embryonic cockroach and eventually locate in the fat body where they soon multiply to form the masses that surround the nuclei of the modified fat cells. This process occurs early in the life of the cockroach, and the very young nymphs already have well-developed bacteriocytes scattered through the body.

These bacteroids have been rather loosely termed intracellular symbionts, although an actual symbiotic relationship has never been proven, and it has been rather generally assumed that they are more probably some sort of quite innocuous parasites which cause no serious damage to their host. The association of the bacteroids with cockroaches is undoubtedly of very ancient origin: they occur throughout the order Blattodea and have much more recently been noticed in the very primitive Australian termite, Mastotermes. Since the termites presumably arose from cockroach-like ancestors during the early geological history of the insects, we must believe that the cockroaches possessed them before that time.

The successful cultivation *in vitro* of the bacteroids of at least one species of cockroach (*Periplaneta americana*) has been reported by Glaser,[1] although this is not easily accomplished, and others have failed to repeat the procedure.

Since the bacteroids react to stains as Gram-positive bacteria, it seemed likely that they might be affected by some of the bacteriostatic or bacteriocidal substances that have recently come into therapeutic use in combating pathogenic bacteria. Consequently, we tried several of the common sulfa-drugs (sulfanilamide, sulfathiazole, sulfadiazene, sulfapyridine and sodium sulfanilate), injecting them in saline solution or suspension directly into the body cavity of a species of Florida cockroach, *Blaberus cranifer*. This is a very large roach, the females measuring nearly two inches in length and weighing on the average about four grams, while the males are noticeably smaller and lighter in weight. The dosages were determined on the basis of the known tolerances of mice per unit of body-weight, but we found that the roaches could receive much greater quantities with no apparent ill effects. None of these treatments had any noticeable effect on the bacteroids, as was determined by killing and fixing the roaches after periods varying from one day to several weeks. In practically every case, the bacteroids showed no significant change in numbers, morphology or staining properties.

A preliminary treatment of a number of roaches was made about a year ago, using the medium in which a culture of *Penicillium notatum* had been grown. An inoculum of this was given to us by Dr. D. H. Linder. It appeared that this material had some effect on the bacteroids, but the results were not constant, due no doubt to the variable concentration of the penicillin employed. More recently we secured through the courtesy of Dr. Chester A. Keefer some penicillin of

[1] R. W. Glaser, *Jour. Exp. Med.*, 51: 59–82, 1930.

known potency, and with this have been able to treat a number of roaches with standardized dosages. The penicillin was dissolved in sterile water in such dilution that the dose desired in each case was contained in 0.2 cc, which is a convenient volume for injection. These injections were repeated, as shown by the appended table, where the effects of the several concentrations is also indicated. It will be noted that the tolerance of the roaches is many times greater on the basis of body weight than the therapeutic dosages employed in human medical practice.

COCKROACHES (*Blaberus cranifer*) TREATED WITH PENICILLIN

Lot No.	Dosage in Oxford Units	Results
A. (2♀)	200 units × 4 doses Total—800 units	After 28 days, one killed and fixed. Separated clumps of symbionts present. Other roach perfectly healthy.
B. (2♀)	200 units × 5 doses Total—1,000 units	After 4 days, one killed and fixed. Symbionts apparently in good condition. After 8 days, another killed and fixed. Symbionts apparently in good condition. Both were lively when killed.
C. (3♀)	400 units × 4 doses Total—1,600 units	After 24 hours, one killed and fixed. No symbionts visible, although the large cells formerly containing them evident. After 26 days, one almost dead, killed and fixed. Symbionts in scattered cells. Fat frothy and almost completely liquefied. After 27 days, third specimen killed and fixed. Condition as in the previous one.
D. (3♀)	800 units × 4 doses Total—3,200 units	After 24 hours, one dead. After 24 hours, one killed and fixed. No symbionts in larger cells, but a very few in smaller ones. After 27 days, the third specimen killed and fixed. Symbionts present in scattered cells.
E. (2♀)	2,000 units × 3 doses Total—6,000 units	After 6 days, one killed and fixed. No symbionts visible. After 12 days, second specimen died.

These results show very clearly that the bacteroids are affected by penicillin when this is administered at high concentrations, although the roaches give no immediate indication of any toxic effect from the drug,[2] even when dosages as great at 200 times the therapeutic dose is injected. The condition of the fat cells and their contained bacteroids were examined after fixation in formaldehyde, sectioning in paraffin and a heavy staining in haematoxylin.

From the data here presented, it is apparent that the administration of penicillin at the lower concentrations very greatly reduces the number of bacteroids, but after the insects are allowed to live normally for a time, the bacteroids gradually increase in numbers. Meanwhile, the roaches show no ill effects from the treatments. If, however, sufficient penicillin is administered to destroy the bacteroids, or to reduce their numbers beyond a very low level, the roaches finally die after some days have elapsed. Since they do not succumb immediately, their death can not be attributed to a direct toxic effect of penicillin, but rather to a lack of something supplied by the bacteroids. We can not regard the present results as conclusive evidence that the bacteroids are necessary for the continued life of the cockroaches, but they make it appear very probable that such is the case and that they are symbiotic, and not parasitic, microorganisms.

[2] Occasionally roaches die shortly after having received an "intraperitoneal" injection, due probably to perforation of the alimentary canal by the hypodermic needle.

CHARLES T. BRUES
RUTH C. DUNN

BIOLOGICAL LABORATORIES,
HARVARD UNIVERSITY

THE OCCURRENCE OF NORMAL SERUM GAMMA-GLOBULIN IN HUMAN LYMPHOCYTES

DESPITE the interest and importance of the problem, there is little information concerning the origin of serum globulins. Since the human serum γ-globulin fraction contains almost all the antibody activity of pooled plasmas,[1] and since numerous attempts to demonstrate antigenic[2,3] and physical[4] differences between immune and non-immune globulins have been uniformly unsuccessful, there would seem to be little doubt that antibodies are modified serum globulins, and that in man, at least, they are chiefly modified γ-globulins.

Recent demonstrations of the occurrence of antibody in lymphocytes of rabbits[5] and mice[6] substantiate earlier indications of the role of lymphoid tissue in the development of immunity.[7] It follows that if antibody is synthesized in lymphocytes, normal serum γ-globulin should also be present.

We have, therefore, prepared rabbit antisera to highly purified γ-globulin fractionated from pooled normal human plasmas, and have found that extracts of lymphocytes of human origin react specifically with these antisera.

The γ-globulin used for immunization[8] was further

[1] J. F. Enders, *Jour. Clin. Invest.*, 23: 510, 1944.
[2] H. P. Treffers and M. Heidelberger, *Jour. Exp. Med.*, 73: 293, 1941.
[3] E. H. Kass, M. Scherago and R. H. Weaver, *Jour. Immunol.*, 45: 87, 1942.
[4] M. L. Petermann and A. M. Pappenheimer, Jr., *Jour. Phys. Chem.*, 45: 1, 1941.
[5] T. N. Harris, E. Grimm, E. Mertens and W. E. Ehrich, *Jour. Exp. Med.*, 81: 73, 1945.
[6] T. F. Dougherty, J. H. Chase and A. White, *Proc. Soc. Exp. Biol. and Med.*, 57: 295, 1944.
[7] C. H. Bunting, *Wisconsin Med. Jour*, 24: 305, 1925.
[8] Kindly supplied by Dr. J. L. Oncley of the Department of Physical Chemistry, Harvard Medical School. See E. J. Cohn, J. L. Oncley, L. E. Strong, W. L. Hughes, Jr., and S. H. Armstrong, Jr., *Jour. Clin. Invest.*, 23: 417, 1944.

purified by the author and found to be 98 to 100 per cent. pure γ-globulin by electrophoretic examination. This degree of purity probably represents the limit of accuracy of the Tiselius apparatus, hence no more precise figures for purity can be given.

Twenty mesenteric lymph nodes were obtained within one hour after death of a patient, a fifty-four year old white female who died of arteriosclerotic heart disease, with pulmonary edema and terminal bronchopneumonia. The nodes were dissected free of fat and connective tissue, washed in saline, and sliced into narrow sections (2–5 mm in thickness) with a razor blade. These slices were suspended in 25 ml of saline, shaken vigorously for 5 minutes, and filtered through cheesecloth. The filtrate, containing about 95 per cent. small lymphocytes and about 5 per cent. large lymphocytes, was centrifugalized and the cells washed twice in 25 ml and finally in 1 ml of saline. The supernate, following the last washing, failed to react with antiserum to γ-globulin. The cells were resuspended in 1 ml of saline and frozen and thawed three times; smears made at this time showed practically all cells to be lysed. The supernate, after centrifugalization, reacted with the antiserum to γ-globulin, and failed to react with normal rabbit serum. If diluted until it failed to precipitate with the antiserum, the lymphocytic extract, when mixed with the serum, inhibited the ability of the antiserum to precipitate purified human γ-globulin or to form a precipitate when overlaid with normal human serum. Extracts of washed slices of human liver failed to react with the antiserum.[9]

The occurrence of normal γ-globulin in lymphocytes, when coupled with the demonstration of lymphoid hyperplasia accompanying antibody production[10,11] and the failure of lymphocytes to adsorb antibody *in vitro*,[5] suggests that the specific alteration of γ-globulin to cause the molecule to become reactive toward a given antigen occurs within the lymphocyte.

EDWARD H. KASS
DEPARTMENT OF PATHOLOGY, MEDICAL SCHOOL,
UNIVERSITY OF WISCONSIN

RETENTION OF THIAMINE, RIBOFLAVIN AND NIACIN IN DEEP FAT COOKING[1]

THE doughnut continues to increase in popularity as shown by the following records of sales in this country: 1929, 201 millions of dozens; 1937, 258 millions; 1939, 336 millions and estimated for 1943, 665 millions. A food material of this importance in the national dietary merits attention with respect to its contributions to the daily regimen. The present report indicates the losses in vitamins which occur in the process of cooking.

The doughnuts were made in a commercial machine. The dough ring is ejected into the hot fat (approximately 375° F.) and rises to the surface due to the immediate leavening action. Half the doughnut is immersed in the cooking fat for 45 seconds, then the doughnut is turned mechanically and for the rest of the 90 seconds total cooking time the other half is immersed.

Quantitative estimations were made of the concentration of thiamin, riboflavin, niacin and iron in the dry doughnut mix containing enriched flour and in the freshly cooked doughnut. The thiochrome method[2] was used for thiamine, the procedure of Snell and Strong[3] using *Lactobacillus casei* for riboflavin and the method of Krehl, Strong and Elvehjem[4] using *Lactobacillus arabinosus* for niacin. The composition of the finished doughnuts (30 gm each) was as follows:

Protein	1.84	gm
Fat	6.03	"
Carbohydrate	14.70	"
Calcium	13.40	mgm
Phosphorus	92.70	"
Iron	0.57	"
Thiamine	0.085	"
Riboflavin	0.066	"
Niacin	0.600	"
Moisture	6.84	gms
Calories	123.6	

Making allowance for the addition of water to the dry mix in preparing the dough and also for the fat absorbed during frying, it was found that the average loss in thiamine during cooking was 22.9 per cent. and in niacin was 20 per cent., whereas there was no measurable loss in riboflavin or in iron.

The loss of thiamine in this type of food in the course of deep fat frying is within the limits observed by Melnick, Oser and Himes[5] in baking various kinds of cake made from enriched flour. They found that as the pH of the cake batters increased from 5.9 to 7.9 the losses of thiamine during baking generally increased. In the present study the pH of the doughnut batter was 6.1, a value not ordinarily con-

[9] Extraction by similar means of lymphocytes obtained from a case of visceral sporotrichosis gave similar results. The nodes in this case, however, could scarcely be called normal.

[10] W. E. Ehrich and T. N. Harris, *Jour. Exp. Med.*, 76: 335, 1942.

[11] A. Rich, *Proc. Soc. Exp. Biol. and Med.*, 32: 1395, 1935.

[1] This study was supported by a grant from the Doughnut Corporation of America.

[2] D. J. Hennessy, *Cereal Chemists Bul.*, 2: 1, 1942.

[3] E. E. Snell and F. M. Strong, *Ind. Eng. Chem., Anal. Ed.*, 11: 346, 1939.

[4] W. A. Krehl, F. M. Strong and C. A. Elvehjem, *Ind. Eng. Chem., Anal. Ed.*, 15: 471, 1943.

[5] D. Melnick, B. L. Oser and H. W. Himes, *Cereal Chemistry*, 20: 661, 1943.

sidered favorable to the destruction of thiamine. Melnick[6] found little loss of niacin during the baking of bread; it would appear, therefore, that the cooking in hot fat exerts a more deleterious effect upon this vitamin than does oven baking. The observation on the stability of riboflavin in the present study agrees with the published results of Andrews, Boyd and Terry[7] on the stability of riboflavin during baking. As would be expected, no loss of iron could be demonstrated.

GLADYS J. EVERSON
ARTHUR H. SMITH

WAYNE UNIVERSITY

EFFECT OF REDUCED ATMOSPHERIC PRESSURE ON HATCHABILITY OF THE HEN'S EGG

THE shipment of hatching eggs by plane from this country to Europe and elsewhere has been proposed as a practical measure in the restoration of depleted stocks of fowl. Describing the results of tests carried out by R. E. Phillips, M. A. Jull states that hatching eggs transported by air from the University of Maryland to Los Angeles and return (maximum altitude, 12,000 feet) and to Miami, Fla., and return (maximum altitude, 7,000 feet) did not differ significantly in hatchability from non-shipped controls.[1] Aside from other considerations, the proposal made by Jull raises the interesting question of effect of reduced atmospheric pressures on subsequent hatchability of the hen's egg. Tests undertaken to clarify this point, at least in preliminary fashion, are reported on at this time.

Eggs were collected from the same flock of Rhode Island Red hens during the two days preceding each test, divided into experimental and control lots, and next morning were weighed and placed in vacuum desiccators. The experimental eggs were maintained under reduced pressure from 9:00 A.M. to 9:00 P.M. during the next three days. The desiccators containing the control eggs were covered but under normal atmospheric pressures during these hours. Covers were removed from all desiccators between 9:00 P.M. and 9:00 A.M. except in the test run at 6.9 inches Hg. At 9:00 P.M. of the third day under test the eggs were again weighed. Incubation was begun the following morning.

Reduced pressures were maintained by a vacuum pump and manually controlled by-passes in all but the test at < 0.5 inch Hg. In this final test the system was under the lowest pressure which the pump could maintain. Pressures were observed against a mercury column. All tests were carried out at room temperatures, which ranged from approximately 70 to 80° F, during hours of test and somewhat lower at night.

Our results are recorded in the accompanying table. Under the conditions of test set forth, the hatch of fertile eggs remains independent of atmospheric pressures over the range 29.9 (controls) to 0.9, and possibly to 0.6 inch Hg. The lower pressure limit (0.9 inch Hg) corresponds to a standard altitude of about 78,000 feet. In view of these data it seems altogether improbable that reduced atmospheric pressure incidental to air transport of fertile eggs might result in subsequently impaired hatchability.

TABLE 1

HATCHABILITY AND WATER LOSS OF EGGS SUBJECTED TO REDUCED ATMOSPHERIC PRESSURE FOR 36 HOURS (12 HOURS DAILY FOR 3 DAYS)

Pressure	Altitude	Eggs set	Fertile eggs		Hatch of fertile eggs		Water loss during test
In. Hg	Feet	No.	No.	Per cent.	Per cent.	T/C	g/100 g
23.6	6,500	138	127	92	80	0.96	0.48
29.9	200	141	130	92	83		0.49
16.2	16,000	136	122	90	87	1.04	0.51
29.9	200	137	123	90	84		0.43
6.9	35,000	130	118	90	92	1.08	...
29.9	200	130	115	88	85		...
5.9	39,000	133	124	93	86	0.97	0.38
29.9	200	133	122	92	89		0.29
4.4	45,000	139	126	91	83	1.05	0.32
29.9	200	140	124	89	79		0.27
0.9	78,000	111	93	84	90	1.01	0.71
29.9	200	107	89	83	89		0.42
0.6	87,000	135	124	92	80	0.95	2.63
29.9	200	132	114	86	84		0.22
<0.5	>90,000	118	98	83	45	0.49	7.57
29.9	200	112	96	86	92		0.36

T/C is the ratio of test to control percentage hatches.

The final test appearing in Table 1 (< 0.5 inch Hg) resulted in the hatch of only 45 per cent. fertile eggs and a water loss of 7.57 per cent. of initial egg weight. This is not an excessive water loss in hatching eggs held for ten days or two weeks, but under test conditions the loss occurred in 36 hours or at the abnormally high rate of about 5 per cent. of initial egg weight daily. We can not exclude the possibility that loss of water at this rate directly or indirectly impairs hatchability.

It is notable that water loss increases only moderately with reduction of pressure from 23.6 to 0.9 inches Hg, but very rapidly as pressures are reduced below 0.9 inch Hg. Hatchability also is affected only by pressures less than 0.9 inch Hg. Further study of the relation between water loss and hatchability at pressures below about 1 inch Hg may prove of possible interest in connection with other and more complex reactions at low atmospheric pressures.

RICHARD M. FRAPS
BUREAU OF ANIMAL INDUSTRY,
U. S. DEPARTMENT OF AGRICULTURE,
BELTSVILLE, MD.

[6] D. Melnick, *Cereal Chemistry*, 19: 553, 1942.
[7] J. S. Andrews, H. M. Boyd and D. E. Terry, *Ind. Eng. Chem., Anal Ed.*, 14: 271, 1942.
[1] Morley A. Jull, *Hatchery Tribune*, 18: 80, 1944.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE USE OF IONIC EXCHANGE RESINS FOR THE PURIFICATION OF PENICILLIN AND HYPERTENSIN

THE selective absorption of inorganic ions by ionic exchange resins suggests the possibility of an interesting method for analysis and purification of mixtures of organic substances obtained from biological materials. We have, therefore, studied the behavior of amines, amino acids and polypeptides filtered through these resins, using to this effect the anionic and cationic exchange resins, Ionac A and C, under the following conditions.

Small funnels with a stem seven centimeters in length and eight millimeters wide are filled with four grams of resin previously subjected to a thorough washing with distilled water. This preliminary washing is essential because the resin releases at first up to 0.2 milligram nitrogen per cc. The removal of this nitrogen does not in any way alter the absorptive activity of the resin.

The anionic resin thus prepared absorbs proteins, long chain polypeptides, a variety of chromogenic substances and a few amino acids; the cationic resin retains in addition most amino acids and in particular basic amino acids and amines. Detailed results of these experiments will be presented elsewhere.

It has seemed to us that these exchange resins could be used for the purification of biological products by removing from the latter certain inactive or toxic impurities. The purification of hypertensin and penicillin will serve to illustrate the potentialities of the method.

PURIFICATION OF HYPERTENSIN

When hypertensin is prepared according to the method of Braun Menendez *et al.*, one obtains a product still somewhat impure and which loses much of its activity when attempts are made to purify it further by means of the usual absorbents. We have found, however, that by treating the crude product with the anionic resin, Ionac A, one can remove several inactive substances; chromogens, polypeptides, etc., without affecting significantly the hypertensive activity. One thus obtains readily a product containing only 0.08 milligrams of nitrogen per unit of hypertensin.

In contrast to Ionac A, the cationic resin, Ionac C, absorbs the active principle of hypertensin. Unfortunately, we have not yet been able to release an active eluate with any of the thirty eluents which we have used, such as salts, bases, acids, detergents, alcohol and other organic solvents, etc.

PURIFICATION OF PENICILLIN

As is well known, cultures of *Penicillium notatum* release, in addition to the antibacterial agent penicillin, a variety of impurities, many of which are toxic, which prevent the use of the untreated filtrate for therapeutic purposes. The classical method employed for the isolation of penicillin is not only time-consuming and expensive, but also causes important loss of the active material.

We have observed that by filtering the crude culture filtrate containing penicillin, first through the cationic resin, Ionac C, at pH 6 to 7, then through the anionic resin, Ionac A, at the same pH, one obtains a product which retains all the penicillin activity of the original material, but which is now free of any toxicity for experimental animals and for man. In fact, the filtrate can be injected by the intraperitoneal route into mice and by the intravenous route into cats, dogs and man without any toxic manifestations. The penicillin preparation thus obtained can be concentrated *in vacuo* at low temperature. It seems likely that this simple procedure will be found useful for the purification of other active substances produced by molds and various biological agents.

E. CRUZ-COKE
F. GONZALEZ
W. HULSEN

DEPARTMENT OF PHYSIOLOGY AND PATHOLOGICAL CHEMISTRY,
UNIVERSITY OF SANTIAGO, CHILE

BOOKS RECEIVED

BENNETT, JOHN W. *Archaeological Explorations in Jo Daviess County, Illinois.* Illustrated. Pp. xiii + 168. University of Chicago Press. $1.75. 1945.

GRAHAM, HERBERT W. and NATALIA BRONIKOVSKY. *The Genus Ceratium in the Pacific and North Atlantic Oceans.* Illustrated. Pp. 209. Publication No. 565 of the Carnegie Institution of Washington. $2.00. 1944.

PIGGOTT, CHARLES S. and ROGER R. REVELLE. *I, Marine Bottom Samples Collected in the Pacific Ocean by the Carnegie on Its Seventh Cruise. II, Radium Content of Ocean-Bottom Sediments.* Illustrated. Pp. 196. Publication No. 556 of the Carnegie Institution of Washington. $2.00. 1944.

SEMAT, HENRY. *Fundamentals of Physics.* Illustrated. Pp. 593. Farrar & Rinehart. $4.00. 1945.

SINGER, T. E. R. *German-English Dictionary of Metallurgy.* Pp. 298. McGraw-Hill. $4.00. 1945.

WEEKS, MARY E. *Discovery of the Elements.* Fifth edition, revised. Illustrated. Pp. 578. Journal of Chemical Education, Easton, Pa. 1945.